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Applied Mechanics Reviews

A Critical Review of the World Literature in Applied Mechanics

A. W. WUNDHEILER, *Editor*

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Applied Mechanics Reviews

A Critical Review of the World Literature in Applied Mechanics

July 1950 Vol. 3, No. 7

Communications

Delays in the publication of reviews

In reply to inquiries from authors and reviewers, we are sorry to say that APPLIED MECHANICS REVIEWS are under a 32-page limit enforced by lack of funds. Our backlog has grown to about 1200 papers, and it continues growing at the rate of about 60 titles per month. We publish all the book reviews we have, and release the other reviews in the order of the publication dates of the papers. All friends of APPLIED MECHANICS REVIEWS are invited to suggest other solutions to this problem. Ed.

Reviewers wanted

APPLIED MECHANICS REVIEWS does not have specialized reviewers for papers in

Russian, on acoustics (all branches);

Dutch, supersonic airfoil and wing theory; airship structures; crack detection.

We appeal to our readers for offers of their services or suggestions for names. Ed.

Query

Mr. I. E. Holden (73 Kingsfield Drive, Enfield, Middlesex, England) requests bibliographic information on the dynamic considerations involved in designing pneumatic appliances, with particular reference to pneumatic jacks or actuators.

Available translations of Russian papers

G. V. Uzhik: **Method of determining the cleavage fracture strength of metals,** Rev. 2, **477; On the unity of strength and plasticity conditions,** Rev. 2, **1269.** By William Fuller Brown, Jr., Sun Oil Company, Newton Square, Pa. Mimeographed.

M. I. Al'muhamedov, **On conditions for the existence of stable and unstable centers,** Rev. 3, **828.** American Mathematical Society, Columbia University, New York, N. Y.

Theoretical and Experimental Methods

(**See also Revs. 1353, 1360, 1370, 1376**)

1202. **H. Blenk, Nomograms for the 4th-degree equation with real or complex roots** (in German), Z. angew. Math. Mech. 29, 58–61 (Jan.-Feb. 1949).

1203. **Hans Bückner, Report on the development of the integrator unit of Rechenautomaten G. m. b. H. Göttingen** (in German), Z. angew. Math. Mech. 29, p. 38 (Jan.-Feb. 1949).

1204. **Johannes Fischer, Determination of function graphs by nomographic calculation** (in German), Z. angew. Math. Mech. 29, 55–56 (Jan.-Feb. 1949).

1205. **H. Heinrich, Comparison of the accuracies of several methods of graphical integration** (in German), Z. angew. Math. Mech. 29, 51–52 (Jan.-Feb. 1949).

1206. **F. K. Rubbert, Quadratic interpolation at large differences** (in German), Z. angew. Math. Mech. 29, p. 54 (Jan.-Feb. 1949).

1207. **E. Weinel, Remarks on the remainder of the Lagrange interpolation formula and of the formulas for numerical differentiation** (in German), Z. angew. Math. Mech. 29, 32–33 (Jan.-Feb. 1949).

1208. **Alvin Walther, Solution of ordinary differential equations by means of the IPM-Ott integrator** (in German), Z. angew. Math. Mech. 29, 37–38 (Jan.-Feb. 1949).

1209. **Heinz Wittke, Mathematical machines and instruments. From the abacus to the ENIAC** (in German), Z. angew. Math. Mech. 29, 34–36 (Jan.-Feb. 1949).

1210. **K. Zuse, Mathematical premises for the development of logistic and combinative calculating machines** (in German), Z. angew. Math. Mech. 29, p. 36 (Jan.-Feb. 1949).

1211. **A. Porter, New methods for the numerical solution of algebraic equations,** Phil. Mag. 40, 578–585 (May 1949).

This paper presents a method for finding the numerical solution of algebraic equations. It consists essentially in factoring a quadratic expression from the given equation and finding the coefficients of this quadratic expression by trial and error after comparison with the coefficients of the original polynomial. The author discusses three general methods which are based on this principle, and shows the procedure used in finding the numerical solution of a specific quartic and sextic equation.

Henry J. Barten, USA

1212. **Glenn Murphy and J. V. Atanasoff, A mechanical device for the solution of equations involving the Laplacian operator,** Iowa State Coll. Engng. exp. Sta. Bull. no. 166, 19 pp. (1949).

The soap-film analogy has been used to solve the equation $\partial^2 z/\partial x^2 + \partial^2 z/\partial y^2 = F$, where F is a known function of x and y. The present paper presents a method of obtaining a more durable model of the surface by modifying a first approximation in a block of material like paraffin. If z_1, z_2, z_3, z_4 are the heights of the surface over the vertices of a small square of edge $2u$ in the x, y plane, and z_0 is the height over the center of the square, then z_0 is approximated by $4z_0 = z_1 + z_2 + z_3 + z_4 - u^2F$. By means of a series of linkages, an instrument adjusts a cutting tool to the height z_0 by taking the mean of z_1, z_2, z_3, z_4 and subtracting the value F which has been set into the instrument. By successive operation of the instrument over the surface, an approximation to the desired shape is obtained. Michael Goldberg, USA

Mechanics (Dynamics, Statics, Kinematics)

(See also Revs. 1220, 1221, 1316)

1213. Bekir Dizioğlu, On the kinematics of linkagelike couplings (in German), Bull. tech. univ. Istanbul 1, no. 1, 11–28 (1948).

Grübler gave the following formulas for f (the number of degrees of freedom of a linkage mechanism) in terms of n (the number of links), and the f_e (the number of degrees of freedom of the separate joints): $f = 3(n - 1) - \Sigma(3 - f_e)$ for plane linkages, $= 6(n - 1) - \Sigma(6 - f_e)$ for spatial linkages. This paper is an exposition of these formulas which are illustrated with various linkage mechanisms. Singular cases, which do not obey these formulas, are not considered. M. Goldberg, USA

1214. Arnold Sommerfeld, Lectures on theoretical physics, vol. I: Mechanics (**Vorlesungen über theoretische Physik, Band I: Mechanik**), Wiesbaden, Dieterich'sche Verlagsbuchhandlung, 1949, xii + 375 pp., 74 figs. Paper, 9 × 6 in., $3.60.

This is the first of a series of volumes on theoretical physics, based on introductory courses given by the author during his many years at the University of Munich. The contents of the volume as indicated by the chapter headings, are: (1) Mechanics of a particle, (2) Mechanics of systems of particles, (3) Vibration problems, (4) The rigid body, (5) Relative motion, (6) Integral principles, (7) Differential principles, (8) Hamilton's theory.

Although the scope of these lectures is confined to classical mechanics, the author's concern with preparing the reader for the study of relativistic and quantum mechanics is made explicit in the opening and closing chapters. Throughout the book the claims made upon the mathematical background of the student are kept within modest bounds. This self-restraint on the part of the author merely reflects the underlying pedagogical objective of the book: demands of rigor and systematic exposition are consciously subordinated to the primary goal of arousing and holding the reader's interest in the subject. The result is a treatment rich in intuitive appeal and abundant with genuine applications selected in equal measure to suit the interests of physicists and engineers. Frequent descriptions of experimental verifications and of demonstration apparatus further tend to make this a singularly lively and stimulating introductory treatise. E. Sternberg, USA

1215. Fausto Fumi, The Hamiltonian equations for holonomic systems acted upon by conservative forces in a generalized sense (in Italian), Atti. Accad. Ligure 5, 338–345 (1949).

The author considers systems of the form

$$d/dt(\delta T/\partial \dot{q}_i) - \partial T/\partial q_i = d/dt(\partial V/\partial \dot{q}_i) - \partial V/\partial_{q_i},$$

where $T = T(q, \dot{q})$ is the kinetic energy and $V = V(q, \dot{q})$ is a generalized potential function. The case when V is linear in the q's is especially considered. The results are trivial.

D. C. Lewis, USA

1216. Antonio Pignedoli, More on the applicability of Jacobi's method to nonholonomic systems (in Italian), Atti Sem. Mat. Fis. Univ. Modena 2, 87–95 (1948).

This is a continuation of the paper of Rev. 3, 22. The author states necessary and sufficient conditions for the consistency of the system of $m + 1$ partial differential equations of the first order for the function V, and gives the characterization of nonholonomic systems to which the Jacobi-Hamilton method of integration is applicable. E. Leimanis, Canada

1217. I. G. Malkin, On Poincaré's theory of periodic solutions (in Russian), Prikl. Mat. Mekh. 13, 633–646 (1949).

Consider a real system Σ_μ:

$$x_s = X_s(t, x_1, \ldots, x_n;\ \mu),\ s = 1, 2, \ldots, n$$

where the X_s are continuous with period 2π in t, and have continuous first partials in the other variables for (x) in a certain region G and $|\mu|$ small. Given the existence of a family of periodic solutions of the system Σ_0 depending upon k parameters, the author discusses quite fully the existence of periodic solutions of Σ_μ generated by those of Σ_0. The same questions had been dealt with previously for analytical systems in a paper by the same author not available to the reviewer [I. G. Malkin, The methods of Liapounoff and Poincaré in the theory of nonlinear oscillations (in Russian), Gostekhizdat 1949].

S. Lefschetz, USA

1218. Hillel Poritsky, The billiard ball problem on a table with a convex boundary—an illustrative dynamical problem, Ann. Math. 51, 446–470 (1950).

The relationship of Birkhoff's famous billiard-ball problem to the transformation of a ring-shaped region R into itself is explained. In this connection several different sets of variables are used. Various forms of the integral invariant of this transformation are also established. "Integrability" of the problem is defined as occurring when there exists a nonconstant function $\lambda(x, y)$ defined over R, such that $\lambda(x_1, y_1) = \lambda(r, y)$, where (x_1, y_1) is the point into which (x, y) is carried by the transformation. This concept of integrability is studied by considering the envelopes of families of chords drawn to the curve which bounds the "billiard table." It is shown, under certain conditions, that this bounding curve must be an ellipse if the problem is to be integrable. Questions of transitivity and finite intransitivity are also considered. The author states that "in the general nonintegrable case the transformation is transitive over the ring." But this has not, to the reviewer's knowledge, ever been proved, and if the statement is merely to be taken as the definition of the general nonintegrable case, it would be of the greatest interest to show that the "general" case may actually occur. Proof of the existence of transitivity in a case when the billiard table is symmetric about two perpendicular lines would probably also furnish the answer to the famous question as to whether formal linear stability in conservative holonomic dynamical systems implies actual stability. The answer would be in the negative.

D. C. Lewis, USA

Gyroscopics, Governors, Servos

1219. M. H. Béghin, Analytical theory of the O. P. L. gyrocompass (in French), Ann. Hydrograph. 8, ser. 3, 57–91 (1949).

In France the OPL Company (Établissements Optique et Précision de Levallois) has recently completed the construction of a gyrocompass of a new type under the direction of Paul Monfraix. The laboratory tests were very satisfactory and the plan was then to put the instrument on board ship for thorough tests at sea.

In this article M. Béghin bases his analysis on Lagrange's equations and develops the theory of the OPL gyroscopic compass in some detail, after a short description of the instrument and its working parts. He gives no comparison of this gyrocompass with those developed in England, Germany, and America, in theory or practice, nor does he give any references to the literature on this subject. W. C. Johnson, USA

1220. **F. K. Rubbert, On the theory of a balanced gyroscope** (in German), Ann. Phys. Leipzig (6) 5, 237–250 (1949).

Rigorous formulas and simple approximations for the "mean" velocities of precession and rotation of the unsymmetric gyroscope under the action of no moments are the chief results of this variation of a classical theory. D. C. Lewis, USA

1221. **G. Grioli, Regular precessions of an asymmetric heavy rigid body** (in Italian), R. C. Accad. Lincei 4, no. 4, 420–423 (1948) = Ann. Scu. norm. sup. Pisa 1 (1947), 43–74 (1949).

In a previous paper [Rev. 2, 156], the author had shown the existence of ∞^2 regular precessional motions of a heavy unsymmetric top. The linear stability of these motions is investigated in the present paper. As four of the six characteristic exponents of the equations of variation are always zero, instability is, in general, the case. For bodies of very special structure, however, stability is possible. The condition for this is the consistency of four equations involving two structural parameters. Also, initial perturbations of certain special types remain small.

The author makes use of a theorem, believed to be new, which gives a certain necessary and sufficient condition that a linear nonhomogeneous system of differential equations with periodic coefficients should have a periodic solution when it is given that the corresponding homogeneous system possesses linear first integrals with periodic coefficients. D. C. Lewis, USA

Vibrations, Balancing

(See also Revs. 1217, 1332)

1222. **St. Rydlewski, Natural vibrations in a truss with rigid joints** (in French), Arch. Mech. stos. 2, 99–119 (1949).

Natural vibrations of trusses with rigid joints are studied by the method of deformations. Transversal and longitudinal vibrations are considered, and by expressing the conditions of equilibrium at each joint, the frequency equation is obtained. Numerical examples are worked out at the end of the paper. The author expects his method to be of particular value in the case of short-span trusses where Pohlhausen's method fails.

Enrico Volterra, USA

1223. **Scott H. Simpkinson, Laurel J. Eatherton, and Morton B. Millenson, Effect of centrifugal force on the elastic curve of a vibrating cantilever beam,** Nat. adv. Comm. Aero. Rep. no. 914, 7 pp. (1948).

See Rev. 1, **401.**

1224. **Max Päsler, The differential equation for the time dependence of elastic vibrations with thermal damping** (in German), Ann. Phys. Leipzig 4, 14–24 (Sept. 1948).

In oscillating elastic bodies, the thermoelastic effect, as is known, produces heat currents which result in the so-called thermal damping. This damping forms the largest part of the internal friction. Former communications have shown that the time dependence of a thermally damped elastic oscillation can be described by a differential equation of the third order if the shape of the oscillator is punctual or axially symmetric (sphere, cylinder).

Starting from the main differential equations of a vectorially developed theory of thermal damping, the paper shows that a representation by a differential equation of the third order can always be realized, whatever the shape of the oscillator. The differential equation is derived in the form

$$d^3F/dt^3 + \gamma d^2F/dt^2 + \omega_0^2(1 + \epsilon/E)dF/dt + \omega_0^2\gamma F = 0$$

$F(t)$ denoting the function by which the time relation of the displacement vector is determined. It is shown that there exists a simple way to develop the value γ, ω_0, ϵ from the physical constants of the oscillator and from other constants which depend on the shape of the oscillator. E is the modulus of elasticity of the body, ω_0 the natural frequency of the oscillator.

In a final statement it is stated that the described phenomenon can be represented by an oscillation coupled with a second motion related only to velocity. Two ways of resolution are indicated.

Ferd. Budinsky, Czechoslovakia

1225. **Karl Federhofer, Rotary oscillations of a circular cylinder with material damping and liquid friction** (in German), Österreich. Akad. Wiss. Math.-Nat. Kl. S.-B. IIa. 156, 573–582 (1948).

The normal modes of rotary oscillation of a cylindrical rod of circular section are considered. Using cylindrical coordinates r, φ, z, the only nonzero displacement is $u(\varphi)(r, z, t)$, and for this problem it takes the form $U(r)e^{i(\gamma z+pt)}$. Here $U(r)$ is determined from the equation of rotary motion, and the stress-strain relation $\tau_{ij} = G\gamma_{ij} + \xi\gamma_{ij}$ for the two nonzero stress components $\tau_{\varphi z}$ and $\tau_{r\varphi}$; G is complex and represents elasticity and hysteresis; ξ represents internal friction. At the cylindrical surface fluid friction is considered by assuming a shear stress proportional to the velocity with a reversed sign. The ends are assumed unstressed. For this system the frequency equation becomes an intrinsic equation in Bessel functions with complex argument. An approximate solution is obtained for small hysteresis, internal and external friction, by expanding to the first order in these terms, for the mode of vibration in which the cross sections are not distorted but rotate relatively to one another. This solution agrees with that deduced from the wave equation in z and t for the transmisssion of torsional waves along the rod.

E. H. Lee, USA

1226. **G. de Vries, On microvibrations of airplanes, generated by periodic forces in the engine-propeller system: a survey** (in French), Off. nat. Étud. Rech. aéro. Rep. 22, 27 pp. (1949).

The vibrations considered are the frequently annoying mechanical vibrations with frequencies of 5 to 100 or 200 cps caused by periodic forces in the engine-propeller system, and amplified by resonance. The floating suspension of the system is stated to be a common cause of trouble, and the calculation of its natural frequencies is said to be difficult if the quite important influence of the flexibility of the wing structure is to be correctly accounted for. An example of vibrations caused by propeller unbalance is discussed. Several methods to eliminate propeller unbalance are considered, and reference is made to a special instrument, allowing rapid correction of dynamic propeller balance in flight.

J. H. Greidanus, Holland

1227. **J. Valensi, On the free oscillatory motion of a heavy viscous fluid in a U-tube; parameter of similitude** (in French), Bull. Ass. tech. marit. Aéro. 47, 417–428 (1948).

A theoretical analysis and the results of experimental studies of the free oscillations of a heavy viscous fluid in a U-tube are given. Assuming laminar flow, the equations of motion are integrated in terms of an infinite series involving time-dependent terms whose oscillatory or nonoscillatory behavior depends on the numerical value of the dimensionless parameter $V = (R^2\omega)/\nu$, where R is the radius of the tube, ω is the natural frequency of oscillation if the fluid had no viscosity, and ν is the kinematic viscosity. When the measured oscillatory amplitude decrement is plotted against V, two regimes of flow are put into evidence.

High-speed photos prove the conjecture that the flow is laminar in one regime ($V<15$), and turbulent in the other ($V>70$).

Stephen H. Crandall, USA

Wave Motion, Impact

(See also Revs. 1299, 1314, 1354, 1377)

1228. D. S. Hughes, W. L. Pondrom, and R. L. Mims, Transmission of elastic pulses in metal rods, Phys. Rev. 75, 1552–1556 (May 15, 1949).

The authors' primary purpose was to measure Young's modulus and Poisson's ratio by observing the velocity of propagation of a plane-wave pulse along a cylindrical specimen of the substance. The technique and results are not original, but the authors' interpretation of secondary observations seems important to this reviewer.

A quartz crystal "pressed against" the plane end of the specimen was driven by a standard electronic equipment to initiate the pulse. A similar crystal served as a pickup at the other end of the specimen. The velocity of the first wave arrival was greater than that for "bar-velocity," $V_E = (E/\rho)^{1/2}$, and corresponded with the dilatational velocity V_D as has been shown by other experimenters. Secondary, tertiary, etc. wave arrivals were recorded at regular intervals behind the primary arrival. The authors explain the secondary arrival as a dilatational wave that has crossed the bar once after its generation at the cylindrical boundary by a rotational wave generated by the crystal at the same time as the primary dilatational wave. A tertiary arrival has crossed the bar twice and so on for the other arrivals. Thus with V_R for velocity of rotational wave, D and L diameter and length of bar, n number of times the wave was delayed, the time t between generation and arrival of a dilatational wave is,

$$t = (L/V_D) + nD(V_D^2 - V_R^2)^{1/2}/V_D V_R,\ n = 0, 1, 2, \ldots.$$

This formula checks with the experimental observations. A more generalized formula is derived allowing for waves reflected from the plane ends of the cylinder. The authors have not given sufficient details of the method of supporting the specimen, nor of the variables concerned with the driving of the bar by the crystal to allow others to check their observations.

This reviewer feels that the authors' observations and explanation of the observed time delays should provide data to begin a more mathematical examination of the phenomena. One observes from their record of wave arrivals in metals that a transfer of amplitude occurs from primary to secondary arrivals, as the bar length increases for a fixed diameter. The accepted elastic-wave-propagation theory does not appear to predict this. Pochhammer's theory cited by the authors does not indicate the generation of a dilatational wave but merely the second-order correction to the bar velocity V_E to allow for bar radius, wave length, and Poisson's ratio.

K. H. Swainger, England

1229. F. A. Fischer, On the total reflection of plane impulse waves (in German), Ann. Phys. Leipzig 2, no. 3/4, 211–224 (Apr. 1948).

The problem of total reflection of plane harmonic (sound) waves is reviewed. Even though the energy is totally reflected (in a time-average sense), yet there is a periodic exchange of energy between the two media. The second medium carries a wave that runs parallel to the plane interface and is damped in the transverse direction.

A bell-shaped incident wave is next assumed, and the reflected and transmitted waves determined. The Dirac δ-function is then used to represent the limiting form of the incident wave. In the case of normal reflection, the reflected and transmitted waves have the same form as that of the incident wave. Under total reflection the shapes of the reflected and transmitted impulses differ from that of the incident impulse. A numerical example is carried through in detail, and curves are drawn exhibiting the disturbance in the two media.

Robert D. Specht, USA

1230. E. H. Kramer and E. J. Lunney, Dynamic measurements during aircraft landings, Proc. Soc. exp. Stress Anal. 7, no. 1, 83–102 (1949).

Extensive measurements were taken of dynamic loads during the landing impact. Accelerations were determined at various points of interest in the structure, loads in the landing gear were measured by strain gages and besides spin-up times, strut and tire deflections and the vertical rate of descent were recorded. Numerous tests were carried out on six aircraft types, ranging from fighters to heavy bombers. The most important conclusions refer to the large dynamic loads that may occur due to flexibility of the landing gear in fore and aft direction.

W. T. Koiter, Holland

Elasticity Theory

(See also Revs. 1236, 1244, 1245, 1246, 1359, 1384, 1386)

1231. S. Ziemba, The stress function in spherical coordinates for axisymmetric stress and strain distributions (in French), Arch. Mech. stos. 1, no. 4, 311–338 (1949).

In this paper the general axisymmetric (torsion-free) displacement, strain and stress field in terms of Love's stress function are transformed from circular cylindrical into spherical coordinates. As an application the author resolves the problem of a right, circular cone under a concentrated axial load at the vertex. No references are given. The general formulas obtained in spherical coordinates are rather awkward, and reflect the fact that Love's approach becomes inconvenient upon departure from cylindrical coordinates.

E. Sternberg, USA

1232. G. Fichera, On the equilibrium of an isotropic homogeneous elastic body (in Italian), R. C. Semin. Mat. Univ. Padova 17, 9–28 (1948).

In a previous note [Atti Accad. Naz. Lincei Rend. 2, 403–408 (1947)] the author announced an application of Picone's method to the problem of elastic equilibrium of a solid with given boundary deformations. The solution was to be developed in terms of a fundamental system of displacements and forces, consisting of Somigliana's displacements (Love's simple solutions) and their derivatives. The present paper presents the details of the solution.

Ed.

1233. E. G. Chilton, Large deformations of an elastic solid (Spanish translation), Informes Constr. 2, no. 18, 10 pp. (1950).

See Rev. 2, 879.

1234. Albert Kammerer, Influence of a couple on the constraints in two-dimensional contact (in French), C. R. Acad. Sci. Paris 228, 1100–1102 (Mar. 1949).

The stresses in two contacting surfaces under the influence of a couple are discussed by means of isoclinic lines.

Wei Zang Chien, China

1235. **M. V. Tesař, Experimental researches on fatigue on grooves of shafts and on hubs of wheels** (in French), Bull. Ass. tech. marit. Aéro. 46, 375–384 (1947).

The fatigue of a keyway transmitting the torque between a shaft and a wheel was investigated as a plane problem, in order to obtain the stress distribution in the indefinite cross section. Photoelastic tests gave the isostatics and the maximum-shear curves. By integration of Lamé-Maxwell's equations, the author derived the stress diagrams for two opposite contact surfaces.

Concentration factors were obtained in terms of the ratio between the total effort and the keyway's transverse dimension.

D. Gentiloni-Silverj, Italy

Experimental Stress Analysis

(See also Revs. 1235, 1255, 1256, 1294)

1236. **H. de Leiris and A. Barat, On stress distribution around a round hole** (in French), Bull. Ass. tech. marit. Aéro. 46, 363–373 (1947).

A plate with a circular hole, the diameter of which was $^1/_4$ of the plate's width, was subjected to plane uniaxial tension. Isostatics were determined by spreading a brittle varnish coating over the plexiglas model and observing the cracks. Composition of the varnish is given. The isostatics agreed closely with those calculated by means of the elastic theory for a plate of infinite width.

Calculations, thus confirmed, were used for deriving the values of the principal stresses. The author presents the curves of simple equivalent tension under the hypothesis that it is determined by the maximum shear. The stress concentration factor at the edges of the diameter normal to the direction of tension is equal to three.

In the discussion the difference is noted between varnishes and lacquers; lacquers must be spread over a preheated material, a procedure which would not be possible on plexiglas.

D. Gentiloni-Silverj, Italy

1237. **Richard S. Stein and Herman Schaevitz, Autographic stress relaxometer,** Rev. sci. Instrum. 19, no. 12, 835–839 (1948).

An autographic stress relaxometer has been designed and constructed for studying the relaxation of the stress of a polymer film elongated to constant length. The force-measuring element is a linear variable differential transformer which measures the distortion of a flexible steel ring and drives a recorder. The sample is elongated to the desired length automatically, and the correct length is maintained by means of a second differential transformer.

Authors' summary

1238. **Viktor Hauk and Eugen Oszwald, On the temperature influence on X-ray back-reflection measurements** (in German), Z. Metallk. 39, no. 6, 190–192 (June 1948).

This paper is concerned with the temperature influence on precision determinations of lattice constants which are obtained by means of back-reflection measurements. The authors point out that temperature deviations must be taken into account if such precision measurements are not performed with elaborate thermostatic control. They offer a correction formula which is dependent on the lattice parameter, the linear coefficient of expansion, and the prevailing temperature condition.

In connection with stress measurements the authors have worked out such correction formulas for iron and aluminum samples, employing the usual technique of gold or silver coating as "standard" stress-free material.

This reviewer believes that this paper may be of considerable importance for X-ray stress measurements of large workpieces and building materials which cannot be subjected to thermostatic control.

S. Weissmann, USA

Rods, Beams, Shafts, Springs, Cables, etc.

(See also Revs. 1268, 1386)

1239. **J. Ratzersdorfer, The snapping load of a slightly curved beam,** Civ. Engng. Lond. 44, 264–266 (May 1949).

The symmetric form of instability of a slightly curved beam is investigated by direct integration of the differential equation of the deflection curve. Diagrams are presented showing the relationship between the critical load and the ratio of the radius of gyration to the initial height of arc for a concentrated central load and for a uniformly distributed load. The case of two equal, concentrated loads, symmetrically disposed is also treated. For high (> 0.2) radius of gyration/initial height of arc ratios, the values calculated from the author's curves agree closely with values given by previous investigators (see Timoshenko, *Theory of elastic stability*, pp. 230–236); for lower values (< 0.2) the critical load calculated by the present method gives considerably lower values. The paper is purely analytical, and no experimental confirmation is afforded.

G. Sved, Australia

1240. **S. S. Manson and W. C. Morgan, Distribution of bearing reactions on a rotating shaft supported on multiple journal bearings,** Nat. adv. Comm. Aero. tech. Note no. 1280, 1–25 pp. (May 1947).

The distribution of reaction forces between multiple plain bearings of statically indeterminate shafts during rotation is calculated. Besides the elasticity of shaft and bearing frame, the hydrodynamic effect of the oil film between the journals and the bearings is also taken into account. Clear mathematical expressions are obtained by supposing linearity to exist between the eccentricity of the journal rotating in its bearings, and the load hydraulically supported by this bearing. The authors calculated two limit cases: in the first, the directions of the load and of the eccentricity are at right angles to one another; in the second, the directions of the eccentricity and of the reaction forces coincide. In the paper, only this second case is presented for a straight prismatic shaft supported on 7 bearings equally spaced. The reaction forces in response to unit forces acting successively in the center plane between two adjacent bearings are expressed as functions of the stiffness parameter, i.e., as the ratio of the proportionality factor of the oil film and the sum of the elasticity factor of the shaft and the bearing frame. It is shown that, above a certain value of the stiffness parameter, all significant reaction forces are opposite to the unit force (contrary to the case of a crankshaft supported by rigid bearings without radial clearance, the case in question shows no directional changes of reaction forces).

During the experimental tests a straight and a conventional crankshaft were successively supported in the crankcase of an aircraft engine. The reaction forces were determined by using strain gages fixed at the back of the bearing shells. The active forces were excited by unbalanced weights. The results agree qualitatively well with the computed ones. The tests undertaken with several unbalanced weights show, however, the non-additivity of the individual reactions. The results indicate that the hydrodynamic effect should be considered in all problems concerning the distribution of bearing reactions of rotating shafts, especially if the bearings are near each other.

Ferd. Budinsky, Czechoslovakia

1241. Cyp. Demars, A note on the hooping of concrete pipes (in French), Bull. Éc. polyt. Jassy 3, no. 2, 160–174 (July-Dec. 1948).

The problem studied is the hooping of concrete pipes subjected to internal pressure by steel wire rolled up under tension. First, the author recalls briefly the classical method used to determine the initial tension to be given to the wire, and the stresses induced in the concrete. Then he proposes an improved method, which has the advantages of indicating the best diameter of the wire and leading to an economy of steel. In the numerical examples treated, the benefit on the weight of wire varies from 10 to 34%.

Ch. Massonnet, Belgium

1242. Dimitri M. Magiros, On the locus of the vertex of a variable catenary: A study of tension in a variable catenary (in Greek), Technika Chronika: 23, nos. 265–266, 99–102 (1946); 24, nos. 273–274, 96–102 (1947).

This paper deals with a solid line (a thread, a chain, or a cable, for example) which is considered to be rigid, completely flexible, at constant temperature, and under the influence of its own weight. One end of the catenary is held stationary and the other end (B) is moved. (The stationary end (O) and end (B) do not have to be at the same plane, but they are in the same vertical plane.)

For every position of end (B) we have a new catenary of equilibrium with its vertex at (A). If (B) describes a line then the (A)'s describe a curve. The problem of studying the locus of (A) for a given movement of (B) is solved in this paper by finding six equations pertaining to the catenary and eliminating five parameters between them, and then selecting the proper solution. These parameters are a function of the coordinates of the vertex (A).

The specific case when (B) moves on a straight horizontal line passing through (O) is worked out completely, and the locus of (A) is found to be $l/2 - y = m^{-1}(e^{mx} - 1)$, where $m = 8y/(4y^2 - l^2)$, l is the span of the catenary, x the distance of a point on the vertex of the catenary, or of a point of the locus from the x-axis passing through (B), and y the distance of a point on the locus from the y-axis passing through point (O).

In the second paper the tension T at any point of the catenary worked out in the special case of the first paper is determined. End (O) is held stationary and end (B) is moved along a straight horizontal line passing through (O). The tension is expressed in terms of the unit weight of the catenary ρ, the vertical distance from (O) to the vertex f, the span of the catenary l, and the half length of the catenary s.

The tension T at any point in the catenary is given by

$$T^2 = \rho^2[f^2/4 + l^4/(64f^2) - l^2/8 + s^2]$$

where T and f are variables and ρ, l, and s are positive constants.

This expression is then studied and the tension in the catenary for various values of f and l is plotted.

Dimitri Kececioglu, USA

Plates, Disks, Shells, Membranes

(See also Revs. 1252, 1253, 1293)

1243. G. N. Polozhiĭ, On a method of solution of some mixed problems of the theory of thin plates (in Russian), Doklady Akad. Nauk. SSSR 66, no. 3, 353–356 (May 1949).

It is shown that the bending of a thin plate bounded by straight lines, with given boundary conditions of deflections and bending moment, can be solved by means of two functions of a complex variable found from the given boundary conditions. One of these functions is found by the method of Dirichlet, and the second by the method of Riemann-Hilbert.

M. M. Gololobov, Czechoslovakia

1244. Eric Reissner, On finite deflections of circular plates, Proc. Symp. appl. Math. 1, 213–219 (1949).

The problem dealt with is the loading of thin, circular, elastic plates when large, rotationally symmetric deformations are produced. By assuming small strains, but making no restrictions with regard to the magnitudes of displacements and slopes, the author shows that the mathematical treatment of the problem can be reduced to a system of two simultaneous differential equations for the slope of the deflected middle surface, and for the horizontal stress resultant of the deflected plate. This result is a generalization of previous and well-known findings of other authors, who restrict attention to the loading range where finite but small deflections are encountered.

The behavior of the equations in the vicinity of a boundary is discussed, and it is shown that the possibility of edge effects exists, i.e., a significant redistribution of the edge stresses in a narrow plate zone adjacent to the boundary can occur. A similar behavior is met with in the small deflection theory of thin shells of revolution, and the author points out the analogy between these nonlinear and linear cases.

No solutions for specific boundary-value problems are given in this paper, but results of this kind will be sought in later work.

Martin Goland, USA

1245. Charles Libove and S. B. Batdorf, A general small-deflection theory for flat sandwich plates, Nat. adv. Comm. Aero. Rep. no. 899, 18 pp. (1948).

See Rev. 1, **799.**

1246. H. Neuber, General theory of shells, II (in German), Z. angew. Math. Mech. 29, 142–146 (May 1949).

In this second part of his paper [see Rev. 3, **1070** for the first part] the author first considers the geometry of the deformation of the shell. In accordance with general practice, transverse shearing stresses and normal stresses are supposed to be negligible. The components of the deformation tensor are then reduced to the components of the components of the displacement of the middle surface and its plane derivatives. The stress quantities L and M are expressed in terms of the quantities k and l, formed in a similar way from the three components of the displacement of the middle surface.

Finally the boundary conditions are investigated. Either the deformation of the boundary or the resulting forces and moments of the load applied along it may be specified. Both cases are dealt with. In the last case three forces and two moments occur, and as this amount is in excess to that compatible with the system of differential equations, the torsional moment is eliminated in a conventional way by replacing it by a pair of forces that are combined with the other forces.

A. van Wijngaarden, Holland

1247. J. Hadji-Argyris, The general theory of cylindrical and conical tubes under torsion and bending loads. Part 6, J. roy. aero. Soc. 53: May, 461–483; June, 558–620 (1949).

This is the sixth and concluding part of a structural analysis of wings. The first five parts were the subject of Rev. 1, 620 (April 1948). The analysis is here extended to multicell tubes with openings, open tubes, and tubes formed by joining elements of different cross sections. In the open tubes the case of vanish-

ingly small Saint Venant torsional stiffness is considered, resistance to torque being then due to warping restraint. A numerical example of a four-boom wing consisting of seven joined elements is fully worked out. An appendix proposes practical methods for tubes which do not conform to the type of wall-thickness variation assumed in the basic analysis, and for finding the stresses in direct stress-carrying walls at cutouts. J. N. Goodier, USA

1248. **J. Tâche, Ring subjected to couples or concentrated forces which are symmetrically distributed over the circumference** (in French), Bull. Tech. Vevey 9, 29–47 (1949).

The following loads are considered for arbitrary cross sections: (1) n equal couples acting in planes through the axis of the ring; (2) n equal couples acting in planes tangent to the circumference and parallel to the axis of the ring; (3) n equal radial forces, each going through the centroid of the cross section; (4) n equal forces P parallel to the axis of the ring, equivalent to a force nP uniformly distributed over the circumference. The stress distribution is determined for these cases. E. Siebel, Germany

1249. **L. P. Zick and C. E. Carlson, Stress analysis of a Hortonsphere,** Weld. Res. Suppl. 14, 205–214 (May 1949).

The paper presents the results of a study conducted to determine the distributions of strains and stresses in the vicinities of the column-to-shell connections of a 48-ft-diam Hortonsphere supported on eight tubular columns. Measurements of strains were obtained for various conditions of loading. These measurements were made by means of SR-4 electric-resistance gages attached to the shell and to the columns. A procedure is described for the preparation of steel, wire leads, and gages when the gages are subjected to hydrostatic pressure.

A comparison is made of the stresses obtained by means of the measured strains, and those computed by means of theory. The authors recommend that the present practice of increasing the thickness of a plate at the connection to a column be continued. In addition, they recommend that the equator plates between columns be the same in thickness as the bottom plates of the shell. Frank Baron, USA

Buckling Problems

(**See also Revs. 1233, 1239, 1245**)

1250. **L. Kirste, An extension of the method of rigidity** (in German), Öst. Ingen.-Arch. 2, 226–229 (1948).

This is a discussion of the analogy between the buckling of an elastically supported beam and the buckling of rectangular plates, and an evaluation of the stability determinant for the case of two infinitely long plates joined in such a way that a V-section is formed, with the two infinite edges of the plate combination simply supported. E. Reissner, USA

1251. **J. H. Hunter-Tod, The elastic stability of sandwich plates,** Coll. Aero. Cranfield Rep. no. 25, 42 pp. (Mar. 1949).

This paper treats the elastic stability of supported rectangular plates of sandwich construction with isotropic and aeolotropic fillings under compression and shear loading. A detailed analysis is first made in which the equations of equilibrium of the core material and the faces of a curved sandwich are established, and the interaction between core and faces is expressed in terms of boundary conditions at the interface. A study of a simply supported flat panel on this basis leads to the conclusion that over a great range of conditions the long-wave buckling stress of flat panels in compression is independent of the form of the filling, and that of its elastic constants only the transverse-shear modulus is of concern. This justifies the author in setting up, as others have done before, a less cumbersome theory in which the sandwich is treated as a plate in which transverse-shear deformations as well as deformations due to bending are taken into account. This theory is applied to the solution of several of the more important special cases. In addition, wrinkling or local failure of the faces of flat panels in compression is investigated.

The reviewer was disturbed by the occurrence of what appear to be unjustified assumptions and rather crude approximations in some instances. For example, the boundary condition $\partial w/\partial y = 0$ is assumed to hold for clamped edges "if the filling is fully constrained," even though the bending stiffness of the faces is neglected. In addition, a partial differential equation of fourth order is given and used for the equilibrium of curved sandwich panels and cylinders. It seems to the reviewer that an ordinary differential equation of fourth order is appropriate for axially symmetric buckling, but that to treat adequately, by means of a single equation, the more general buckling problems considered, an eighth-order partial differential equation would be required. S. B. Batdorf, USA

1252. **Paul Seide, Compressive buckling of flat rectangular metalite type sandwich plates with simply supported loaded edges and clamped unloaded edges,** Nat. adv. Comm. Aero. tech. Note no. 1886, 19 pp. (May 1949).

A theoretical solution is obtained for the compressive buckling stress of flat rectangular sandwich plates with simply supported loaded edges and clamped unloaded edges. The buckling stress derived from the small deflection theory for flat sandwich plates [Nat. adv. Comm. Aero. tech. Note no. 1526 (1948)] is presented in graphical form in terms of the plate aspect ratio and a core shear-flexibility coefficient. Although the solution applies for stresses within the elastic limit, a correction for plasticity is suggested. Good agreement between theoretical and experimental results is recorded. The average discrepancies are 5.6% for panels with cellular-cellulose-acetate core, and 28.2% for panels with end-grain balsa-wood core. Conrad C. Wan, USA

1253. **C. H. Norris, Localized buckling of structural members,** J. Boston Soc. civil Engrs. 36, no. 3, 281–308 (July 1949).

A theoretical solution of buckling stress for the case of long plates, supported intermittently along the long sides, is presented and compared with some recent test data. Critical stress is expressed in the form of Bryan's formula,

$$\sigma_{cr} = K\pi^2 E t^2/12(1 - \nu^2)b^2,$$

in which K is given by

$$K = \{(1 - g/b)^2[1 + (nb/1)^2]^2 + 2(g/b)^2\}/\{(1 - g/b)^2(nb/1)^2 + 2(g/b)^4\}$$

g^2 is the spacing of intermittent point supports along long sides, and n is the number of buckles. Various width-thickness and gap-width ratios for web plate and outstanding legs of angles and flanges are also recommended. Minglung Pei, USA

1254. **N. Dewulf, On the deformation of underground penstocks** (in French), Houille blanche 4, 269–284 (May-June 1949).

Underground cement-injected penstocks are sometimes subject to buckling, for the exterior water coming from the surrounding soil may fill the narrow space between the penstock wall and the cement envelope. Special reinforcing is thus necessary.

As the design of these reinforcings rests upon the knowledge of their initial elastic deformations, the author has derived formulas to evaluate them. The theory is based on the ordinary analysis

of curved beams, and covers different cases which are met with in practice. Charles Massonnet, Belgium

Joints and Joining Methods

(See also Rev. 1249)

1255. Arthur R. Anderson, Improving bolt performance, Prod. Engng. 20, 109–111 (May 1949).

Photoelastic investigations carried out on stress distribution in bolts and nuts are described and the results discussed. Although it should be recognized that the two-dimensional models tested did not conform rigorously to the three-dimensional systems of stresses in the bolts and nuts, it was observed that the regions of maximum stress in the models coincided with the fatigue-fracture locations. It seems therefore that although a photoelastic study of this kind does not yield exact quantitative stress data, it can give much information of a qualitative nature.

Enrico Volterra, USA

1256. E. von Burg, Experimental determination of static-stress distribution in rivets in junction of single-row rivetings (in German), Schweiz. Arch. 15, 137–145 (May 1949).

In experimental work on the title problem, not many of the modern possibilities of measuring strain and stress are used. However, the author obtained results of very high accuracy by an ingenious application of the measuring method used. It is shown that the stress distribution in a single-row rivet joint is more uniform if the shear rigidity of each rivet is chosen in accordance with its position. The method of riveting with all rivets having the same rigidity is shown to lead to a local static stress in the junction that is unnecessarily high. The tests were made on junctions of noncorrosive plates with rivets of the same material. Ragnar Nilson, Sweden

1257. T. W. Greene, Evaluation of effect of residual stresses, Weld. Res. Suppl. 14, 193–204 (May 1949).

This paper, which relates an evaluation of the effect of residual stresses by means of bend tests and impact tests, introduces some unique cases of treating impact and bend-test data. The author concludes among other things that it is very difficult to evaluate the effect of residual stresses upon the mechanical properties of welded plates and other weldments, but that he can show qualitatively the effects of furnace stress relieving welded plates and weldments. The stress-relieved plates were 10 to 15% higher as far as load-carrying capacity was concerned, and were somewhat more ductile than the nonstress-relieved weldments.

R. G. Sturm, USA

1253. Viktor Hauk, On the internal stresses of spot-welded connections (in German), Z. Metallk. 39, no. 9, 276–279 (Sept. 1948).

The method of E. Strauss is extended from page 162 of the 1939 *Jahrbuch der Deutschen Luftfahrtforschung*, and applied to the computation of radial and tangential stress components produced in 140-mm diam, 2.6-mm thick, manganese steel disks when a single spot weld, or six arranged in two rows of three each, is made. Stresses are computed in the vicinity of the single weld, and between the multiple welds. Stresses measured by the X-ray technique using a gold-powder indicator are found to be in good agreement with the computed values. It is shown that outside the heat-affected zone of the weld the radial and tangential stresses are approximately equal in magnitude, opposite in sign, and vary as $1/R^2$ where R is the distance from the weld center. The measured stresses are so nearly the same on both surfaces of the disk that no third-dimension effect is apparent.

Joseph S. Newell, USA

1259. Stefan Soretz, Electrical flash-welding of as-received steel for reinforcing concrete (in German), Z. Öst. Ingen.-Archit.-Ver. 94, 23–26 (Feb. 1949).

In this paper the author gives the results of exhaustive experiments with flash-welded mild steel for reinforcing concrete of ultimate strength ~52 kg/mm.^{2} He arrives at the following conclusions: (1) Manually operated flash welders yield welds the strength of which is 20% below the ultimate strength of the unwelded material. For fully automatic flash welders the corresponding figure is 10%. (2) It is possible to restore the full strength of flash-welded parts by means of cold work. The best procedure to achieve this is to remove the seam and to twist a 6-in. length containing the weld through an angle of 30 deg. (3) If, however, the welding is done on a machine of suitable size, the process is constantly supervised and samples are frequently tested, then it is possible to guarantee full strength of the joint. The author therefore proposes to alter the German standard specification DIN 1045 pertaining to welded mild steel sections for reinforcing concrete, in the sense that there is no decrease in strength of flash-welded round steel of marks 1 and 2.

M. Gololobov, Czechoslovakia

Structures

(See also Revs. 1222, 1230, 1241, 1247, 1249, 1252, 1259, 1389)

1260. E. W. Parkes, The design of redundant structures for minimum weight, Aircr. Engng. 21, 162–163 (May 1949).

The design of a redundant structure of minimum weight, consisting of end-load-carrying members and shear-carrying members, is elucidated for the example of a circular frame, consisting of two concentric booms, connected by a sheet web, and loaded by two equal moments of opposite signs; cross tensile stresses in the web are neglected. The results are presented in graphs. In the reviewer's opinion the results can only hold for structures that cannot fail by instability. Moreover the general reasoning leading to equations (vi) and (vii) is considered erroneous; this error does not affect the specific results of the example.

W. T. Koiter, Holland

1261. G. Magnel, Design of the ends of prestressed concrete beams, Concr. constr. Engng. 64, no. 5, 141–148 (May 1949).

An appropriate distribution of the pressures under the anchorages of the prestressing cables is of great importance for the behavior and the safety of the prestressed beam. A reasonable method of computing the tensile principal stresses at the ends of a concrete beam would therefore be of practical value. An exact solution of this problem can hardly be expected.

In the author's book, *Prestressed Concrete* (London, 1948), such an approximate method was given. As it exaggerates the stresses, an improved method is being proposed, from which the dangerous principal tensile stresses at any point of the rectangular anchorage end block of the beam may be derived. The results obtained are compared with the results of tests and good agreement is found.

W. Olszak, Poland

1262. K. Woods, Influence of subgrades and bases in design of rigid pavements, J. Amer. Concr. Inst. 21, no. 5, 329–348 (Jan. 1950).

The author believes that the problems of pavement pumping and subgrade strength evaluation do not have an exact solution,

and should be approached with the regional-soil concept in mind. After a general survey of the subject, the author gives a list of 99 bibliographic references. Ed.

Rheology (Plastic, Viscoplastic Flow)

(See also Revs. 1257, 1286, 1287)

1263. **A. A. Il'yushin, Some fundamental problems of the theory of plasticity** (in Russian), Izv. Akad. Nauk SSSR Ser. tekh. Nauk no. 12, 1753–1773 (Dec. 1949).

The paper represents an address delivered before the general session of the Technological Section of the Academy of Sciences of the USSR in June 1949. The author surveys past Russian work in the mathematical theory of plasticity, forecasts future trends, and takes issue with physicists and metallurgists who have criticized this theory as ignoring the known structure of metals. With regard to such criticism, the author emphasizes the desirability of a physical theory of plasticity but states that engineers will have to use the present phenomenological approach at least until such a theory is developed. He also points out the possibility that even when a physical theory of the plastic deformation of polycrystalline metals is developed, it may turn out that it is far too complex to lend itself to the analysis of stresses and strains in machine parts or structural members of complicated shapes. From the author's survey of past Russian work, it appears that the theory of small elastic-plastic deformations, a "finite" (as opposed to "incremental") theory is definitely established in Russia as the appropriate tool of stress analysis in problems of contained plastic deformation (as opposed to problems of unrestricted plastic flow). The author indicates the well-known limitations of this theory but states, without giving details, that its predictions have never been found to involve errors of more than 7 to 10%. W. Prager, USA

1264. **J. C. Fisher, Anisotropic plastic flow,** Trans. Amer. Soc. mech. Engrs. 71, 349–356 (May 1949).

Stress-strain relations for plastic deformation of isotropic and anisotropic metals are derived on the basis of a large number of assumptions. The basic one is that during slip over an area A, elastic energy is relieved in a volume equal to that of a sphere with great circle A, and the plastic strains observed are a summation of elastic strains relaxed in the neighborhood of a large number of slip bands. Incremental stress-strain relations are taken in the form $de_{ij} = \lambda \partial W^*/\partial \sigma_{ij}$, where W^* is the difference between the strain energy per unit volume before and after slip. The von Mises form is obtained for isotropic polycrystals on the further assumption that the slip process relieves all shear stresses in the slip region, leaving the stress system hydrostatic. A simple anisotropic form requires taking the stresses after slip to be linear functions of the applied stresses. D. C. Drucker, USA

1265. **Hsiao Chih-Chun, The distribution of residual stresses in the rolling process,** Proc. Soc. exp. Stress Anal. 6, no. 2, 141–149 (1948).

Bars of rectangular cross section 1 in. × 2.43 in. cut out from a 1-in. thick plate of 99.45% pure aluminum, after annealing at 750 F, were rolled at room temperature between 6-in-diam rolls. The percentage of reduction in thickness was 10, 20, and 30 in the specimens, taken in a single pass, or in 10% sequences. After the flat bars were thus cold-rolled, X-ray back-reflection pictures were taken of them, and the residual stresses in the surface in them determined in the direction of rolling and in the direction of width. The rolled flat bars were then sliced up, and the distribution of the residual stresses in them in the direction of rolling across the thickness determined by means of the relaxation method using wire strain gages. The author publishes a number of interesting curves indicating the distribution of the residual stresses in the direction of rolling, and also in the direction of the width of the specimens. These curves were symmetric with respect to the middle sections. The surface stresses were found to be compression stresses in all cases. Just below the surface the stresses change very rapidly and become tensile stresses which decrease toward the middle plane of the rolled sheet where they are again compression stresses. Residual tensile stresses of the order of 9000 lb/in.^{2} were observed in their peak values. In one figure a distribution of the residual stresses is given in a space diagram over the entire cross section (width times thickness) which illustrates the variation of the stresses also along the direction of width. A. Nádai, USA

1266. **Paul Bastien and Pierre Azou, On the influence of hydrogen on cohesion of steel** (in French), C. R. Acad. Sci. Paris 228, 1651–1653 (May 1949).

Results of tension tests to fracture of a low-carbon (0.15%C) steel loaded with hydrogen are compared with those of the non-hydrogen-treated metal, assuming that the difference between the total necked-down section A before fracture and the part ΔA of this section over which intercrystalline fracture occurs as a result of weakened cohesion (while separation over the remaining part is due to subsequent shear) is a significant variable. It is found that the stress $P/\Delta A$, where P denotes the load at fracture, is a linear function of $(A - \Delta A)/\Delta A$, the zero intercept of which at $\Delta A = A$ is assumed to represent the true cohesion of the metal. The fracture stresses $P/\Delta A$ are considerably reduced by the hydrogen content. A. M. Freudenthal, USA

1267. **Georg Masing, Can a metal melt temporarily during the plastic deformation?** (in German), Z. Metallk. 40, no. 3, 89–93 (March 1949).

This is a critical discussion of the problem whether a metal can melt considerably below its normal melting point as a result of the nonuniform pressure experienced in plastic deformation. Thermodynamically the contemplated large depression of the melting point can only be accounted for by assuming the presence of a semipermeable wall. This assumption, however, is not realized in plastic deformation; rather the respective model by Gibbs, Riecke, and Tammann appears to be approximately correct. Consequently, in plastic deformation the melting temperature of a metal cannot be depressed considerably.

Transient melting during plastic deformation can, however, take place through local temperature increase as a result of heat generated by internal friction. Hans F. Winterkorn, USA

Failure, Mechanics of Solid State

(See also Revs. 1283, 1288, 1293)

1268. **H. de Leiris, On fractures of external shafts due to progressive cracking** (in French), Bull. Assoc. tech. Marit. Aéro. 46, 385–392 (1947).

The author analyzes fractures of ship-propeller shafts caused by flexural-fatigue loading. Such loading may result from bearing misalignment, initial shaft curvature, or pulsating propeller-blade forces. Corrosion-fatigue effects are shown to be of significance in these applications. Four service fractures, illustrated in detail, are analyzed fully. In each case, the appearance of the fracture permits conclusions as to its cause. G. A. Nothmann, USA

1269. J. W. Beams, Some experiments on the bursting of spherical rotors by centrifugal forces, Proc. Soc. exp. Stress Anal. 7, no. 1, 1–6 (1949).

This paper describes high-speed destruction tests on a number of steel spherical rotors of various sizes. Some of the rotors used were very small, the smallest being 0.21 in. in diameter. This made it possible to obtain extremely high speeds. The speed reached on the .021-in. ball before it exploded was 40 million rpm and gave a centrifugal acceleration of 430 million times gravity. Theoretically the bursting speed of a rotor is proportional to the square of the peripheral speed. Similarly shaped rotors of the same material should burst at the same peripheral speed, regardless of the OD. Practically, however, this is not so. The highest possible speed before bursting, based on elastic theory, is rarely attained because of material imperfections. The author found that with increasing smallness in the size of the rotors, the actual bursting speed approached the theoretical value. The rotors were tested in a high vacuum by means of an axial magnetic suspension, being spun by a rotating magnetic field. The electromagnetic circuit diagrams are given Results are tabulated for tests on several rotors. E. G. Allen, USA

1270. H. P. van Meer and F. J. Plantema, Fatigue of structures and structural members (in Dutch), Nat. LuchtLab. Amsterdam Rap. 357, 66 pp. (Aug. 1949).

This report contains the results of a search of the literature concerning fatigue of materials and structures, which was carried out as a preparation for the establishment of a program of fatigue tests. It forms a continuation of an earlier report [Nat. LuchtLab. Amsterdam Rap. 301 (1945)].

Attention has been given mainly to general principles, rather than to an evaluation of the mass of experimental data available in the literature. After a section in which some well-known definitions and general remarks are recapitulated, there follow sections dealing with various circumstances on which the fatigue strength may depend, the statistical theory of fatigue failure, and various known methods for improving the fatigue strength.

In section 5 some data are given on the fatigue strength of structural components (mainly joints) which are common in aeronautical design. From authors' summary

1271. Karl Wellinger and Artur Hofmann, Testing of metallic materials at low temperatures (in German), Z. Metallk. 39, no. 8, 233–239 (Aug. 1948).

Tensile tests and fatigue tests under reversed axial load were made on specimens of pure aluminum and of two aluminum alloys containing Mg and Mn. The tensile tests were made on specimens of uniform section and on specimens with a 60-deg notch at the center section, at room temperature −60 C, and −183 C using an efficient cooling chamber developed for the purpose. Lateral contraction at the point of necking, lateral contraction far from the point of necking, elongation in 5 cm, and stresses for the 0.2 offset yield strength, for the beginning of necking, and for fracture were measured in each case. It was found that none of these properties decreased with decreasing temperature and that some of them, notably the elongation of the pure aluminum and the stresses for all three metals, increased appreciably with decreasing temperature.

The fatigue tests were made on specimens of uniform section 6 mm in diameter at temperatures of 20 C, −55 C, −75 C. In this case also there was a distinct increase in fatigue strength with decreasing temperature, particularly for the fatigue strength (cycles to failure) at high stress amplitudes.

The results are compared with previously reported data for the temperature effect on mechanical properties of other metals. It is pointed out that a decrease in properties with decreasing temperature has not been found in face-centered cubic crystals (Cu, Al, Pb, Cd, γ-iron), while it has been found in volume-centered cubic crystals (α-iron) and in hexagonal crystals (Zn, Mg, Cd).

Walter Ramberg, USA

Material Test Techniques

(See also Revs. 1228, 1257, 1269, 1279, 1288, 1289, 1290, 1361)

1272. Phillip Eisenberg, Morris S. Macovsky and Walter L. Stracke, A six-component dynamometer for the measurement of forces and moments on models of ship appendages, David Taylor Model Basin Rep. no. 692, 17 pp. (May 1949).

A description is given of an instrument for measurement of the forces and moments about the principal axes of models of ship appendages adapted for either translational or rotational retraction. Development of the instrument, its calibration and methods of deriving forces and moments from its data are described.

It consists of a model-supporting platform supported by three horizontally disposed rings for measuring drag and side forces and three vertically disposed rings for measuring vertical forces. Strain-gage elements located in strain-gage circuits are connected to the rings. The entire device is secured to a towing carriage for applying the forces to be investigated. The question of turbulence stimulation is considered.

The writer questions the advisability of using the term "dynamometer" for apparatus of the type described, since it measures only forces or moments, and the term dynamometer implies apparatus also registering distance-time factors for determining power. At least, a prospective reader should be advised that the paper discusses dynamometers in the special sense of force and moment-measuring apparatus as such.

Lloyd R. Koenig, USA

1273. C. A. Zapffe, C. O. Worden and F. K. Landgraf, Fractographic examination of ship plate, Weld. Suppl. 14, 126–135 (Mar. 1949).

The authors describe a microscope technique of examination and classification of the metallic surfaces resulting from fracture of metals under embrittling conditions (such as low temperatures).

The fracture patterns, called fractographs, were correlated with the toughness of ship-plate steels as indicated by temperatures of transition from ductile to brittle fracture in tension tests of 12- and 72-in. plates and in Charpy impact tests. Toughness is described as characterized by a rough coral-type pattern and absence of crystallographic markings. Lack of toughness is indicated by expansive, flat facets marked with crystallographic registrations which may even show a block structure when crystallographic units have pulled away along secondary cleavage planes.

The authors list three principal factors as influencing toughness: atomic cohesion, transgranular traverse, and intergranular traverse. These three factors are described as contributing increments of force required for cleavage. In this statement the authors' concept of toughness is not entirely clear since toughness is commonly related to energy rather than force.

William N. Findley, USA

1274. Robert J. Hansen, Long duration impulsive loading of simple beams, J. Boston Soc. civ. Engrs. 35, no. 3, 272–285 (July 1948).

One of the variables which influences the response of mechanical

systems and structures to impulsive loading is the force-time curve of the load. In the work under review, this curve is trapezoidal in shape and its duration, which ranges between 0.01 and 1 sec, is longer than the fundamental period of the systems under investigation. The results presented are tentative and refer to reinforced-concrete beams supported near their ends and loaded at their centers; when the loads were such that they just caused cracking, the stresses in the concrete were of order 1.1 to 2.5 times the ultimate strength of the material, while the steel sustained stresses ranging between 2.5 to 3.5 the static-yield stresses. The loads, strains, and deflections were measured by electronic, photographic, and mechanical methods. For producing the trapezoidal force-time curve, a high-pressure cylinder-piston apparatus was developed, giving a normal load of 10,000 lb and capable of an occasional overload of nearly twice this figure.

This work differs from previous work in two respects: (a) the novelty of the design of the loading apparatus, and (b) here, the duration of the impulse is longer than the period of the system, whereas previous work has been concerned with the converse situation. R. M. Davies, Wales

1275. **William C. Schneider and Charles J. Burton, Determination of the elastic constants of solids by ultrasonic methods,** J. appl. Phys. 20, 48–58 (Jan. 1949).

R. Bowling Barnes and Charles J. Burton, Visual methods for studying ultrasonic phenomena, J. appl. Phys. 20, 286–294 (Mar. 1949).

Charles J. Burton and R. Bowling Barnes, A visual method for demonstrating the path of ultrasonic waves through thin plates of material, J. appl. Phys. 20, 462–467 (May 1949).

The second paper listed above discusses the general technique of the use of striae methods for the study of refraction, diffraction, and interference in ultrasonic waves as they travel through a liquid-filled tank with two opposing glass sides.

The first and third papers discuss the variations in these waves which are produced when a thin plate is immersed in the liquid in the tank, and the way in which either electrically or visually these variations can be observed and used to determine moduli of elasticity in tension and in shear in the material of the plate.

When a beam of ultrasonic waves strikes against the plate, part of the beam is reflected, the angle of reflection equaling the angle of incidence. Two refracted beams are formed in the solid, one of shear and one of dilatation waves. These beams recombine on emerging from the far side of the plate. Since the wave velocity in the solid is usually greater than the velocity in the liquid, the wave trains in the solid are refracted away from the normal. If the plate is rotated about an axis perpendicular to the sound beam, the intensity of the emergent beam through the liquid will show a series of fluctuations due to interference between the two waves, a marked minimum at the angle at which the dilatation waves are totally reflected, and a drop to zero at the angle of total reflection of the shear waves. Since at the points of total reflection, the sine of angle of incidence is equal to velocity in liquid divided by velocity in solid, these angles give the velocities of the dilatation and shear waves and so the two moduli of elasticity. The interference effects may also be used to obtain moduli of elasticity. Moduli so determined are given for aluminum, copper, and steel, and agree fairly well with statically determined values. Moduli are also given for a number of plastics.

Mortimer F. Sayre, USA

1276. **J. M. M. Pinkerton, On the pulse method of measuring ultrasonic absorption in liquids,** Proc. phys. Soc. Lond. Sect. B, 62, 286–299 (May 1949).

The two physical constants of materials which can be found by ultrasonic techniques are the velocity of sound and the absorption coefficient for sound. The latter can be found by several methods, and the author gives reasons for preferring the pulse method for liquids. In this method, short trains of waves (usually 10 to 20 waves long) are radiated by a piezoelectric crystal. After transmission through the liquid, the wave train is either picked up by another crystal, or is reflected from a plane surface and picked up by the source crystal. The electronic apparatus necessary to produce and detect the pulses is very similar to that used in radar. Formulas are given for both the Fresnel region (where the distance from the crystal of radius R, radiating waves of length λ, is less than R^2/λ) and for the Fraunhofer region, where the distance is greater than R^2/λ. The experimental precautions to be observed when making measurements in either region are discussed. Typical apparatus is described in detail; included are descriptions of the tank for holding the liquid, technique of supporting the crystals, irises and reflectors, and the electronic apparatus. Instructions are given for setting up the apparatus and making measurements. Richard K. Cook, USA

1277. **Georges A. Homes, On the opacity of porous mediums to ultrasonics** (in French), C. R. Acad. Sci. Paris 228, 1695–1697 (May 30, 1949.)

In order to investigate the possibility of determining the amount of inclusion or the porosity of a liquid or solid by means of ultrasonic waves, experiments have been made on the attenuation of sound in water filled with bubbles, and in paraffin with metallic inclusions. The ultrasonic transparency of water filled with bubbles was measured and found to be only 2% of that for degassed water for a frequency of 1 megacycle. The transparency increased with the time of degassing, and with no visible bubbles is 87% of that for a well-degassed liquid. A correlation was found between the ultrasonic transparency and the transparency of the liquid to X-rays.

For paraffin charged with metal balls of 5-mm and 1-mm diam respectively, the transparency for ultrasonic waves was 10% and 2% respectively, of that for pure paraffin. The conclusion is drawn that it is possible to evaluate the amount of porosity or of inclusion by the transparency of liquids or solids to ultrasonic waves.

Warren P. Mason, USA

1278. **Herbert F. Schiefer, Lawrence E. Crean, and John F. Krasny, Improved single-unit Schiefer abrasion testing machine,** J. Res. nat. Bur. Stands. 42, 481–497 (May 1949).

An abrasion-testing machine is described. It can be adapted for testing a great variety of materials including woven, knitted, and coated fabrics, plastics, paper, leather and other materials.

The abrasive wear of each material was found to be extremely uniform over the abraded area. Plastics showed a rate of abrasion which was directly proportional to the amount of plasticizer. The abrasive wear in tests of woven fabrics appeared very similar to that which occurred in service. For textiles a quantitative method for measurement of the amount of abrasion, based upon the change in electrical capacitance of the specimen with abrasion, was described. It can be used to obtain an isoruin map of an area of a trouser leg, for instance. This map shows very clearly a number of areas at which excessive abrasive wear in service had occurred. These quantitative measurements of the amount of abrasion were also compared with the decrease of the weight and with the air permeability of woven specimens.

The change of the abradant during abrasion tests was discussed. Silicon-carbide paper decreased very greatly in abrasive power; a spring steel-blade abradant remained essentially constant. Hans Drescher, Germany

Mechanical Properties of Specific Materials

(See also Revs. 1233, 1259, 1265, 1266, 1273, 1274, 1278)

1279. G. E. Bennett and R. M. Davies, An experimental investigation by a dynamical method of the variation of Young's modulus with temperature, J. Inst. Metals 16, 759–776 (May 1949).

The authors report the effect of temperature on the modulus of elasticity of a number of ferrous and nonferrous metals. The modulus of elasticity was determined by determining the natural frequency of vibration for an end-loaded cantilever beam. The beam was vibrated electromagnetically. The specimens were 2.5 cm in length. The temperature range was from room temperature to +550 C. Frank J. Mehringer, USA

1280. Werner Köster, Considerations on the modulus of elasticity of metals and alloys (in German), Z. Metallk. 39, no. 5, 145–160 (May 1948).

The article is based upon a compilation of observed values of the modulus of elasticity for a great number of various metals and alloys. By studying other physical properties and crystal and intercrystal structures of these metals, the author arrives at the opinion that there is a rather narrow correlation between the modulus and many of the physical properties; for instance, the melting temperature and the atomic number of the element. The temperature influence and the effect of the ferromagnetic state are also considered. Of special interest is that in a saturated magnetic state an obvious increase of the modulus can be observed. Considerations on the shear modulus and Poisson's ratio, in connection with the general considerations on the modulus of elasticity, are made. Ragnar Nilson, Sweden

1281. R. V. G. Sundara Rao, The elastic constants of sodium tartrate and rochelle salt, Proc. Indian Acad. Sci. Sec. A, 30, 173–180 (Oct. 1949).

The elastic constants of sodium tartrate and Rochelle salt are determined by the ultrasonic method. The results are discussed along with the existing data on Rochelle salt. The constants of sodium tartrate are determined for the first time.

Author's summary

1282. R. V. G. Sundara Rao, Elastic constants of alumina (in English), Proc. Indian Acad. Sci. Sec. A, 29, 352–360 (May 1949).

The six independent elastic constants of corundum (Al_2O_3 with crystal structure belonging to space group $D_3{}^6{}_d$ of the trigonal system) were determined by the ultrasonic method on sections cut from a boule (grown out of molten Al_2O_3) after determination of the optic axis. Experimental procedures and equations required for the evaluation of the experimental data are given. The values obtained in units of 10^{11} dynes cm^{-2} are, respectively: $C_{11} = 46.6$; $C_{12} = 12.7$; $C_{13} = 11.7$; $C_{14} = 9.4$; $C_{33} = 50.6$; $C_{44} = 23.5$. The elastic surfaces are drawn.

Hans F. Winterkorn, USA

1283. A. W. Dana, E. L. Aul, and G. Sachs, Tension properties of aluminum alloys in the presence of stress-raisers; I. Effects of triaxial stress states on the fracturing characteristics of 24S-T aluminum alloy, Nat. adv. Comm. Aero. tech. Note no. 1830, 55 pp. **II. Comparison of notch strength properties of 24S-T, 75S-T, and 24S-T86 aluminum alloys,** same source, no. 1831, 62 pp. (Mar. 1949).

I. The effects of circumferential V-notches of varying depth and sharpness were investigated for tensile test bars of 24S-T aluminum alloy. If the notch were sharp, the specimens machined after heat treatment were found to be less strong and ductile than those machined before heat treating, whereas for mild notches no difference was observed. The authors attribute this difference to a "surface effect" in that sharply notched bars fractured from the root of the notch, but for mildly notched bars fracturing began in the center. They did not consider possible differences in residual stress states developed by the different methods of processing.

The authors use Ludwik's concept of a fracture-stress function intersecting a flow-stress function as the condition for fracture. By assuming that for mildly notched bars the flow stress k equals the difference between maximum and minimum principal stresses ($S_1 - S_3$), and that the hypothetical fracture stress in pure tension is $^1/_2 (k + S_f')$, where S_f' is the average stress at fracture, a relation between the fracture stress S_f and the flow stress is derived, incorporating Bridgman's equations for a necked-down tension bar. The test data as interpreted in terms of this approximate analysis indicate that for increasing triaxiality of stress in ductile metal the fracture strain decreases, but the actual fracture stress increases. For sharp notches which fracture from the surface the problem was too complex for any direct analytical correlation.

II. This study is a continuation of that of the preceding paper, including tests of 75S-T and 24S-T86 aluminum alloys. Additional data are presented on the notch strength, fracture stress, and ductility, as measured by reduction of area in notched bars. Interpretations are made in terms of a "notch-strength ratio" (i.e., nominal stress in notched section at fracture divided by the tensile strength of the material) which does not appear to the reviewer to be of basic physical significance. The results are also compared with previous tests by the authors on steels. They conclude that for a given notch shape the decrease in ductility due to the notch is very different for different metals; the ductility of aluminum alloys was reduced less by notching than that of the heat-treated steels. The notch sensitivity with respect to ductility was not related in a simple manner to the notch sensitivity regarding strength. No definite relation between ductility and strength could be derived for the aluminum alloy.

Thomas J. Dolan, USA

1284. Wilhelm Puzicha and Alfred Krisch, The influence of the elongation speed on the tension strength and elongation of austenitic steels (in German), Z. Metallk. 40, no. 3, 93–98 (March 1949).

The authors report the results of tensile tests at varying rates of deformation on six austenitic steels: three chrome-nickel (18.8 with varying molybdenum content) and three chrome-manganese. The rate of head travel was between 5 and 1500 mm per min. The test specimens were machined from sheet stock, 1 mm thick.

The authors found that the tensile strength and the per-cent elongation increased with decreasing rate of deformation. The behavior is attributed to the transformation of the austenite in the cold-worked material; the more complete this transformation, the slower the deformation. The severity of the effect of varying the rate of deformation decreases with the stability of the austenite. Frank J. Mehringer, USA

1285. Egon Schmiegelow and João Mendes França, Tensile strength and chemical composition in gray cast iron (in Portuguese), Inst. Pesquisas Technol. Publ. Separata no. 211, 27–40 (1949).

Considerations and data are presented to show that the constant a in the Heller-Jungbluth equation: $\log \sigma_d = a \log (d/30) - \log \sigma_{30}$ (σ_d and σ_{30} being the tensile strength values for diameters d and 30 mm, respectively) can be related to the chemical composition of gray cast iron and specifically to the "degree of saturation"

"*Ge*" defined by Heyn as: $Ge = \%\ C/(4.23 - \%\ Si/3.2)$; a becomes $1.46 - 2.08\ Ge$. Using this relationship, the authors modified the H.-J. abacus to make possible prediction of tensile strength for any diameter within approximately 5% if *Ge* and the strength of specimens having a diameter of 30 mm are known.

Hans F. Winterkorn, USA

1286. **G. Sachs, L. J. Ebert, and W. F. Brown, Jr., Notch-tensile characteristics of a partially austempered, low alloy steel,** Trans. Amer. Inst. min. metall. Engrs. 176, 424–435 (1948).

The authors determine certain mechanical properties of a partially austempered and subsequently quenched SAE 5140 steel by means of tensile tests of $^1/_2$-in-diam bars with a circumferential 60 deg V-notch of sharp root radius, whose depth provided a 50% reduction in cross section. The notch strength (ratio of maximum load to initial area) and the contraction in area at the notch were measured. It was found that small quantities of intermediate-temperature transformation products constituted embrittling factors when present in a matrix of hard martensite. However, when the mixed structure was tempered at a sufficiently high temperature, it possessed approximately the same properties as a pure-tempered martensite of the same hardness. Austempering for sufficient time to produce complete transformation resulted in a structure that possessed properties approximately equal to tempered martensite of the same hardness. The data are of interest from a qualitative viewpoint, but the authors give no consideration to the manner in which residual stresses developed in heat treating may have influenced the test data.

T. J. Dolan, USA

1287. **D. J. McAdam, Jr., G. W. Geil, D. H. Woodard, and W. D. Jenkins, Influence of strain aging on the fracture stress of low-carbon steel,** Trans. Amer. Inst. min. metall. Engrs. 176, 436–447 (1948).

Two different types of low-carbon steel are experimentally studied: a 0.01% ingot iron, and a 0.12% carbon steel. Both materials were annealed. The specimens were circular in cross section and unnotched. The fracture stress was determined in tension tests. The primary interest in this investigation is concentrated on the effect of plastic deformation and strain aging at room temperature on the fracture stress at −188 C. The results confirm that plastic deformation and strain aging will increase the fracture stress both at room temperature and at −188 C. An interesting feature is that the specimens were machined to a smaller diameter for the tests at the low temperature. The influence of this operation is not discussed by the authors. A comprehensive literature index is connected to the article.

Ragnar Nilson, Sweden

1288. **Johan Gorrissen, Some notes on brittleness in mild steel,** J. Iron Steel Inst. 162, 16–28 (May 1949).

The author discusses the effect of cold work, heat treatment, grain size, and several alloying elements on the brittleness in steel. He uses as his index of brittleness the Charpy impact test, the test specimen having a keyhole notch which is the standard in Norway. The location of the transition range in the energy-temperature curve is his criterion of brittleness. Since the author is primarily interested in the performance of steel chains, the carbon content of the steels investigated ranged from 0.03% to 0.18%. In addition to the impact results, a number of photomicrographs are included.

The author arrives at the following conclusions: (1) Chains should be annealed at temperatures above A_3 to avoid the coarse ferrite structure resulting from lower temperature anneals. (2) By fast cooling rates the transition-range temperature is lowered, due partly to a finer ferrite grain size and partly to a more beneficial pearlite-cementite structure. (3) Since a fast cooling rate may cause embrittlement due to quench aging, unkilled mild steels are not ideal chain materials. Introduction of silicon, manganese, and aluminum aids in the control of grain size and aging so that a superior chain material is obtained.

Frank J. Mehringer, USA

1289. **Joseph Marin and William Shelson, Biaxial fatigue strength of 24S-T aluminum alloy,** Nat. adv. Comm. Aero. tech. Note no. 1889, 41 pp. (May 1949).

Fatigue tests on tubular specimens, made of 24S-T aluminum alloy, are described. The specimens were subjected to biaxial tensile stresses. The ratio of these biaxial stresses was varied. A dynamic testing machine has been developed to produce the required stresses which pulsated with about 5 cps. S-N diagrams up to 5×10^6 cycles for four principal stress ratios were plotted. The biaxial stresses have been kept in phase. An agreement between theory and experimental data could not be obtained. The uniaxial fatigue strength in the transverse direction of the tubular specimens was approximately 60% of the fatigue strength in the longitudinal direction.

R. K. Bernhard, USA

1290. **Walter H. Price and George B. Wallace, Resistance of concrete and protective coatings to forces of cavitation,** J. Amer. Concr. Inst. 21, no. 2, 109–120 (Oct. 1949).

A machine used for producing cavitation erosion in the laboratory is described, and the results of tests made to investigate the effect of mix proportions, surface treatment, and protective coatings on the resistance of concrete to cavitation are discussed. Through proper use of these, the resistance of concrete surfaces to cavitation erosion may be extended three or four times, but even the best concrete will not resist the forces of cavitation for a prolonged period. Heavy rubber coatings bonded well to the surface of the concrete have proved effective.

Authors' synopsis

1291. **Fernando Parissi, A method to accelerate the hardening of lime and pozzuolana mortars** (in Italian), G. Gen. Civ. 87, no. 10, 534–538 (Oct. 1949).

The author claims that if a small per cent (about 15%) of the pozzuolana added to the lime to make a mortar is ground as fine as cement, the mortar strength as a function of time increases much faster, and by using the correct dosage it is possible to have this way a series of mortars changing their hardness at will. The author thinks, however, that more tests are necessary to have a better knowledge of the phenomena.

A. J. Durelli, USA

1292. **H. Manche, The "humid" sulfocement in the laboratory and in the field** (in French), Rev. Matér. Constr. no. 404, 162–164 (May 1949).

This paper discusses the preparation of "wet" sulfocements with laboratory and in practice, and accounts for the wide variance in strength as due to improper mixture of the constituents.

Louis F. Coffin, Jr., USA

1293. **A. W. Voss and C. B. Norris, Creep tests of sandwich constructions subjected to shear at normal temperatures,** For. Prod. Lab. Rep. no. 1806, 37 pp. (May 1949).

Creep-time curves are reported for tests under shear loading of sandwich constructions of glass-fabric faces and cellular or honeycomb cores made from glass-fabric, cellulose acetate, paper, and hard rubber. Time-to-fracture data are also presented for these materials.

The construction with a paper honeycomb was the most rigid and had the highest creep strength at any time over the period of the tests. It was observed that the creep rate decreased at first and then increased before fracture. However, it may be of interest to note that the reviewer's creep tests of materials similar to those of which the sandwich constructions were made did not show any region of increasing rate of creep. Hence we may conclude that this phenomenon was a property of the sandwich or cellular structure rather than the material. The behavior may have resulted from fracture of the core, as suggested by the authors, or from other structural changes such as large deformation or buckling of cellular components.

William N. Findley, USA

Mechanics of Forming and Cutting

(See also Rev. 1265)

1294. Robert Kamm, Morris Steinberg, and John Wulff, Plastic deformation in metal-powder compacts, Trans. Amer. Inst. min. metall. Engrs. 171, 439–456 (1947).

The authors use the lead-grid method to study the distribution of strains and the consequent distribution of densities in cylindrical metal-powder compacts. They embed a nitric-acid etched grid made of thin-sheet lead in the vertical axis of symmetry of the cylinder, and measure the deformation after radiography is taken of the compressed powder. In several tests the authors vary the height and diameter of the cylinder, the powder used and the pressure applied. They find, in most of the cases, a very large difference in the densities of the different points, caused mainly by friction on the side walls. To decrease the variations of density, the authors think it is more important to lubricate the walls than to lubricate the particles. The computations are conducted under the assumption that the specimen is under a unidimensional state of strain. The authors do not seem to be aware of a paper by Schunk [Z. Ver. dtsch. Ing. 72, no. 13, 445–447 (1928)] who used a grid embedded in gelatin.

A. J. Durelli, USA

Hydraulics; Cavitation; Transport

(See also Revs. 1227, 1290, 1307, 1344, 1363, 1366)

1295. Albert Schlag, General hydraulics and fluid mechanics (Hydraulique générale et mécanique des fluides), Paris, Dunod, 1950, 220 pp., 111 figs. Paper, $10 \times 6^1/_2$ in., 1400 fr. ($4).

Books in the field of hydraulics and fluid mechanics tend either to adhere to a standard pattern, which is generally acceptable to most readers but offers nothing new, or to follow the particular bent of the author, which usually differs from the customary but thereby provides new food for thought. Professor Schlag's book, reflecting as it does some 25 years of instruction and experimental research at the University of Liége in Belgium, displays to a considerable degree the latter tendency. The first third of the book deals with what is essentially classical hydrodynamics, albeit reduced to a relatively simple form and elucidated by the author in a rather original manner. The last two thirds presents the methods of classical hydraulics, again clarified in the light of the author's experience. Connecting these two rather distinct methods of attack is a section on the principles of mechanical similarity, derived from the fundamental flow equations and used as the basis of the more empirical material which follows. The chapters have, in sequence, the following titles: Properties of fluids; Hydrostatics; Kinematics of fluids; Dynamics of perfect fluids; Steady flow with constant energy; One-dimensional flow (*courant*); Real fluids; Mechanical similitude; Flow along a fixed boundary; Flow in uniform conduits; Local conduit losses; Practical calculation of conduits; Branching conduits and networks; Flow in open channels; Orifices, weirs, and spillways; Cavitation; Measurement of discharge and velocity; Water hammer, surges. The text is rather sparsely illustrated, documentation is at a minimum, and the relative shortness has required the omission of many aspects of each subject. The author's point of view, however, is most refreshing.

Hunter Rouse, USA

1296. Charles W. Harris, An engineering concept of flow in pipes, Proc. Amer. Soc. civ. Engrs. 75, 555–577 (May 1949).

The author describes the general principles of the flow of fluids in pipes, especially the transition from partial to full turbulence. An explanation is given of the discrepancy within this transition between the results of Nikuradse's experiments and the results of experiments with pipes with natural surface.

An approximate formula for partial turbulence is proposed: $f = 0.0061 + 0.55/R^{1/3}$, f being the usual friction factor and R the Reynolds number. For experiments with rough pipes the author has artificially produced a random roughness of a constant absolute mean size on sheet-steel linings. A uniform coating of stainless steel was sprayed on the sheet steel from which the linings were cut, and the linings were annealed and formed to fit the inside of standard pipes. The experiments are carried out for 5 different diameters between 0.294 in. and 3.898 in. (resulting ID), and show that the change from partial to full turbulence for this constant roughness occurs suddenly at substantially the same mean velocity for all 5 diameters, when the experiments are corrected for difference in viscosity. The author uses this result and the above mentioned formula for partial turbulence to derive a formula for full turbulence: $f = 0.0061 + (f_1 + 0.0061)/D^{1/3}$, D being the diameter of the pipe in feet and f_1 the friction factor for a pipe with diameter 1 ft and the same inner surface as the pipe in question. f_1 is called specific roughness coefficient and must be found experimentally. The author prefers this measure for the roughness instead of the equivalent sand roughness found by comparison with Nikuradse's results, as these fail in the transition domain.

From the two formulas for partial and full turbulence an expression for the velocity at the change from one domain to the other is found: $V_t = 0.55^3\nu/(f_1 + 0.0061)^3$, ν being the kinematic viscosity of the fluid.

The two resistance formulas are approximations; the formula for full turbulence is thus based upon the independence of V_t of the diameter. This is, in the opinion of the reviewer, a good approximation for relatively smooth pipes, as, e.g., those used by the author by the experiments, but for greater relative roughnesses, which the author has apparently not taken into consideration, it is less accurate.

Besides the above mentioned experiments the author presents experiments with a moderately rusty 2-in. standard black pipe, a 2-in. brass pipe, etc. Finally the author gives diagrams for the two resistance formulas and a table with specific-roughness coefficients f_1 for different pipe materials with corresponding index velocity V_t at the temperature 55 F.

Hans Thygesen Kristensen, Denmark

1297. Ch. Bouvet, Frost in penstocks (in French), Houille blanche 4, 245–247 (May-June 1949).

Means for avoiding the freezing of water in conduits exposed to the air during periods of very low temperature are discussed. The currently recommended practice is to maintain a velocity of 0.5 meters per sec in the conduit. However, this procedure is

wasteful of water power, and consequently a more economical technique has been developed in which the water temperature is carefully monitored; and, when there is danger of freezing, a quantity of flow, Q, is set up, given by

$$(C/SK) \ln [(\theta_H - T)/(\theta_B - T)]$$

where S is the exposed area of a portion of the conduit at whose ends the water temperatures are θ_H and θ_B, T is the air temperature, C is the specific heat of the water, and K is the coefficient of heat conduction between the wall of the conduit and the surrounding air. Louis Landweber, USA

1298. **L. Escande, New methods for the calculation of surge tanks (Méthodes nouvelles pour le calcul des chambres d'équilibre)**, Paris, Dunod, 1950, vii + 557 pp. Mimeograph. Cloth, 7.5 × 11 in., 2100 fr. ($6).

In an extensive treatment of a wide variety of surge-tank problems, the author indicates in detail two methods of solution designated as the finite-difference method and the semigraphical method. These are applied to a wide variety of surge-tank designs, such features as head loss in the conduit, restricted inlet to the surge tank, overflow from the surge tank, several surge tanks on the same line, compound lines, and surge tanks with variable cross sections being treated in various combinations.

The basic differential equations of energy and continuity are derived for numerous types of installation, and application of the conventional method of numerical stepwise integration is discussed. For problems in which the computations are extremely long, a method is recommended in which part of the computations are performed graphically and part numerically.

In addition to full algebraic detail, numerous figures and tables of detailed computations are included. Various representative problems for which the functional integration can be completed are solved by each of the three methods and the results are compared, the approximate methods leading to the prediction of larger surges than the exact, and hence to a conservative design. John S. McNown, USA

1299. **J. Lamoen, On Allievi's water-hammer problem with consideration of continuous pressure-head losses** (in French), Bull. Centre Étud. Constr. Génie civ. Hyd. Fluviale 2, 355–382 (1947).

The method of characteristics is applied to the analysis of water-hammer phenomena in conduits of uniform diameter and wall thickness, with consideration of wall-friction effects. Wall friction is assumed to be either a linear or a quadratic function of flow velocity. In the last part of the paper the method is extended to account for the changes of cross-sectional area produced by the internal pressure fluctuations. Joseph V. Foa, USA

1300. **Jean Dieudonné, Experiments at sea with propellers in cavitation regime** (in French), Bull. Ass. tech. Marit. Aéro. 46, 253–270 (1947).

A translation of this article has been reviewed as Rev. 1, **1287**.

1301. **Waterways Experiment Station, Method of operation of the Birds Point-New Madrid floodway, Missouri,** Wways. exp. Sta. tech. Memo. no. 2-300, 34 pp. (Aug. 1949).

This model study of the Birds Point-New Madrid floodway, located just below the confluence of the Ohio and Mississippi Rivers, was conducted to establish the method of floodway operation which would utilize the floodway capacity to the best possible advantage and thus effect the greatest reduction in flood stages at Cairo, Illinois. Water-surface elevations at critical points along the river were also studied. Ed.

1302. **Waterways Experiment Station, Wave and surge action Monterey harbor, Monterey, California,** Wways. exp. Sta. tech. Memo. no. 2-301, 24 pp. (Sept. 1949).

Harbor model studies on an undistorted model, linear-scale ratio 1:100, revealed that the proposed breakwater was inadequate for long-period waves of relatively high amplitude, that shore end connection was not advisable, and that the more expensive impervious-type breakwater was no better than the less costly pervious-type. Ed.

Incompressible Flow: Laminar; Viscous

(See also Revs. 1344, 1345, 1368, 1374, 1394, 1395, 1406)

1303. **Bruno Eck, Technical fluid dynamics (Technische Strömungslehre)**, 3rd ed., Berlin, Springer-Verlag, 1949, x + 398 pp., 372 figs. Cloth, 8.75 × 6 in., price DM 27 ($6.48).

This is the third and greatly enlarged edition of a well-known German book which first appeared in 1940. The book is written specifically for the practicing engineer and for the more advanced engineering student. Its professed aims are (a) the presentation of the fundamental laws of fluid dynamics in simplest form, and (b) a presentation of those results of theoretical and experimental research which are primarily of practical importance. Mathematics is kept to a minimum of differential and integral calculus, and the understanding of the basic laws in their application to actual problems is effected by a large number of graphs, figures, and numerical examples. A great number of excellent photographs aid in the visualization of many flow problems.

After a few pages on hydrostatics in chapter I, chapter II presents the equations of motion, introduces the concepts of vorticity, circulation, and potential flow, and presents the flow past the cylinder and sphere as examples of the method of sources and sinks; a detailed explanation of graphical methods is given, and also examples of the use of conservation of energy and momentum in some calculations. Chapter III deals mostly with one-dimensional problems with friction and with flow in pipes, but a considerable portion of it is devoted to the problem of turbulent mixing in combustion chambers. Chapter IV is a presentation of problems of resistance and drag where flow separation is considered. Chapter V deals with the motion of solid bodies in moving fluids, sedimentation of dust, pneumatic transport of grainy materials, and technical methods of separation of powdered materials according to size.

These five chapters constitute the major part (about $^3/_4$) of the book; the chapter on airfoils (previous editions) has been rewritten and enlarged by consideration of questions of interest in turbine design, flow past vanes, and profiles. Two very short chapters on means to avoid flow separation and on cavitation follow. In a chapter on gas dynamics the fundamental thermodynamic relations are presented, followed by Prandtl-Busemann's graphical method for two-dimensional supersonic flow, and a qualitative discussion of shock waves, condensation shocks and thin airfoils in supersonic flow. The last chapter deals with fluid measurements and instrumentation. H. K. Forster, USA

1304. **Ratip Berker, On some properties of the curl of a vectorial field vanishing at its boundary** (in French), C.R. Acad. Sci. Paris 228, 1630–1632 (May 23, 1949).

In this note Berker interprets a paper by Kampé de Fériet [Math. Mag. 21, 74–79 (1947–48)] in hydrodynamic terms, and extends the treatment to three-dimensional flow in a limited region. Berker states four theorems (without proof) that may be very useful in theoretical hydrodynamics. His fourth theorem is analogous to Kampé de Fériet's, and by means of it he finds he

is able to round out the classic problem of determining velocities from vorticities in a closed space. The solution to this problem has been presented by Milne-Thomson (*Theoretical Hydrodynamics*, Macmillan, 1938, p. 488).

W. C. Johnson, Jr., USA

1305. S. G. Popov, On the helical motions of an ideal fluid (in Russian), Vestnik Moskovskovo Univ. no. 8, 35–47 (1948).

A helical motion is defined by the condition

$$\omega_x/U = \omega_y/V = \omega_z/W.$$

A survey of papers (going back to 1881) dealing with such motions and their applications is presented. Ed.

1306. V. P. Starr, A mathematical theory of convection, J. Met. 6, 188–192 (1949).

The author points out that if in a two-dimensional flow without body forces a stream function is given, then the density, temperature, and heat-source distributions may be calculated. However, convection usually implies a body-force field such as that of gravity, and always involves problems in which the heating is specified and the flow field is unknown. Hence, although this appears to be correct fluid-flow theory, the reviewer fails to find in it a contribution to convection theory, and feels that the title is inappropriate and that the meteorological applications are very limited by the indirect approach. Wallace D. Hayes, USA

1307. Roger Huron, On the uniqueness of the solutions of Helmholtz's problem of conformal representation: (polygonal obstacles); (rough obstacles) (in French), C. R. Acad. Sci. Paris 228: 290–292; 357–358 (1949).

Extending J. Leray's work, J. Kravtchenko established an existence theorem for Helmholtz's problem of conformal representation arising for a sharp obstacle, with a finite number of angular points, placed in a channel with rectilinear and parallel banks. The author completes those results by discussing uniqueness in the particular case of a polygonal obstacle. The method used is that of Leray's.

The second paper extends these results to the case of an obstacle formed of fairly regular arcs, forming a contour with a finite number of angular points. However, in this case the conclusions apply only to obstacles with points turned upstream. J. Kravtchenko, France

1308. Gérard Couchet, Two-dimensional unsteady motions with constant circulation and the infinitely close motions (in French), Off. nat. Étud. Rech. aéro. Rep. no. 31, 79 pp. (1949).

An extensive mathematical analysis is presented of the problem of nonsteady two-dimensional potential flow past an airfoil of finite thickness. General equations are derived for the vortex discharge at the trailing edge of airfoils with circulation varying in accordance with the Kutta-Joukowsky condition. A method of successive approximations is used to solve these equations, the first approximation being a steady-state motion. For unsteady motions which are infinitely close to the steady-state motion, the shed vortices approximately follow fluid-particle trajectories of the steady-state motion and, to that order of approximation, the circulation and vortex wake can be determined as functions of the time.

Expressions are derived for the forces acting on an airfoil in a nonsteady motion which is infinitely close to one with constant circulation. It is shown that for the particular case of a thick wing in translation with zero average circulation, the expressions for the force and moment have the same form as those which Theodorsen (and Ellenberger) established for airfoils of vanishing thickness. Gerald E. Nitzberg, USA

1309. Kwei-Lien Chang, The potential flow around given wing sections, J. aero. Sci. 16, 306–310 (May 1949).

By means of the von Kármán-Trefftz transformation, a given wing section can be transformed into a circlelike profile. After changing the rectangular coordinates of points of the boundary to polar coordinates ρ_0 and φ_0, ρ_0 is expressed as a Fourier series of φ_0. With the coefficients of this series the complex potential of the circlelike profile can be written out as an exponential series, and then the complex potential of the given wing section is obtained by some simple substitutions.

The method gives quite good results near the trailing edge, as well as near the leading edge, and it applies to the field as well as to the boundary. The labor involved is equal to that required in the first approximation of the von Kármán-Trefftz method. The accuracy achieved depends on the number of terms retained in the series. Using six harmonics the error is only an order of 0.05%.

When the region near the trailing edge is not considered important, the Joukowsky transformation may be used as an initial step to reduce the labor. R. J. Legger, Holland

1310. M. I. Zhukovskiĭ, Determination of a purely circulatory flow past a lattice of profiles (in Russian), Prikl. Mat. Mekh. 13, no. 4, 457–458 (1949).

Let P be a point on a single profile or on a profile belonging to a parallel lattice. Let ϕ be the value at P of the potential of a purely circulatory (incompressible) flow past the profile or lattice, and let α be the angle of attack of a circulation-free flow for which P is a stagnation point. The author shows that if the units are chosen properly, $\alpha = 2\pi\phi$. L. Bers, USA

1311. Fukusaburo Numachi, Kenji Tsunoda, and Ichiro Chida, Cavitation tests on six profiles for blade elements; Cavitation tests on Clark Y profiles of several thickness ratios; Cavitation tests on special profiles for blade elements (in Japanese), Rep. Inst. high Speed Mechanics, Tohoku Univ. 1, 1–16, 17–30, 31–43 (March 1949).

With a view to providing data on airfoils suitable for blade elements of high-speed hydraulic machines, several airfoils were tested in the water tunnel at the Tohoku University, Sendai. Lift and drag were measured for cavitation coefficient k_d [$= (p_0 - p_d)/(\rho V^2/2)$, p_0 and V the pressure and velocity of the undisturbed stream, p_d the vapor pressure] ranging from 0.2 to 3.0. Visual observations were also made to determine the inception of cavitation. The first report refers to the tests on three airfoils, Clark YH and RAF 6, each of which being of the thickness ratios 6 and 11.7%, the second report on Clark Y airfoils of thickness ratios ranging from 4 to 14%, and the third report on special airfoils of three different thickness ratios somewhat resembling the laminar-flow airfoil. Itiro Tani, Japan

1312. E. Carafoli, Calculation of wings with cut-outs or with local projections (in French), Bull. Sec. Sci. Acad. roum. 30, 198–200 (1947).

The author has written previously (Théorie des ailes monoplanes d'envergure finie, Mémoire scientifique de l'Académie Roumaine, Bucarest, 1944) a comprehensive monograph on monoplane theory. In this note he describes a method for correcting the theory for a standard plan form for local changes in the effective chord length, such as those due to wing cutouts or nacelles. If the effective chord length is $c = c_1(1 + \epsilon)$, where c_1 is the reference chord, the angle of attack is replaced by $\alpha' =$

$\alpha + (\alpha - u_m/V_0)\epsilon$ where α is the actual local angle of attack and u_m an estimated local value of the downwash. With this fictitious angle of attack the reference chord length is used with the standard theory. Wallace D. Hayes, USA

1313. **J. E. Adamson and E. G. Barnes, Low-speed model tests on the effect of nose and gap details on elevator characteristics,** Rep. Memo. aero. Res. Counc. Lond. no. 2326, 28 pp. (1949).

This report contains a rather complete study of the effects of elevator-nose shapes, gap details, and sealing "curtains" on the hinge moment, lift, and drag of the elevator which was required for design purposes. Considerable quantitative information is provided for the particular tests conducted, and some discussion of the effect of "curtains," of incidence, and expected effects of nose shape and gap is included. E. Arthur Bonney, USA

1314. **Benjamin Milwitzky, A theoretical investigation of hydrodynamic impact loads on scalloped-bottom seaplanes and comparisons with experiment,** Nat. adv. Comm. Aero. Rep. no. 867, 16 pp. (1947).

On the assumption that the flow at any cross section of a seaplane float during landing is two-dimensional, the author computes the normal loads with the aid of the virtual-mass concept. The calculation of the required virtual-mass coefficients is discussed, and the resulting equations of motion are integrated numerically. The agreement of the calculated results with limited experimental data is, for the most part, satisfactory. The reviewer is not convinced that the virtual-mass concept is sufficient for the calculation of the normal forces, for, even though the flow may satisfy Laplace's equation in any transverse plane, it does not follow that the axial and cross flows are independent, as evidenced by the corresponding approximate theory for the aerodynamics of slender bodies [G. N. Ward, Quart. J. Mech. appl. Math. 2, 75–97 (1949)]. The reviewer also questions the author's conclusion that the *total* reaction is normal to the keel, since wave drag must be of not inconsiderable importance at typical landing speeds. John W. Miles, USA

1315. **Shigeo Uchida, Slow viscous flow past closely spaced spherical particles** (in Japanese), Rep. Inst. Sci. Technol. Tokyo 3, 97–104 (Mar.-Apr. 1949).

Slow viscous flow past a swarm of spherical particles forming a simple cubic lattice is considered. With the usual notations, the fluid velocity in a unit cube surrounding a spherical particle is assumed in the form:

$$u = Ar^2/5\mu + E/2\mu r + A' + E'/r^3 - f(r)x^2/r^5,$$

$$v = f(r)xy/r^5,\ w = f(r)xz/r^5,$$

$$f(r) = -3(Ar^5/30\mu - Er^2/6\mu + E'),$$

which satisfies the linearized Stokes equations for viscous flow. The arbitrary constants A, E, A', E' are determined by the appropriate boundary conditions. The drag coefficient of the sphere is given by $\psi_s \equiv D/(\rho U^2\pi a^2)/2 = 24R^{-1}F(\alpha)$, where $R = 2aU/\nu$ is the Reynolds number, $F(\alpha)$ a definite function of $\alpha = 1 - (\pi/6)(a/l)^3$, the porosity, and a and l are respectively the radius of the sphere and the edge of the cube. As

$$a/l \to 0,\ F(\alpha) \to 1 + 1.671(a/l).$$

Next, the drag coefficient of a pervious layer consisting of spherical particles of radius a is defined as $\psi_p \equiv (\Delta p/L)(2a/\frac{1}{2}\rho U^2)$, where Δp is the pressure drop in, and L the thickness of, the layer. It is shown that $\psi_p = (\pi/4)(a/l)^3\psi_s = R^{-1}G(\alpha)$, where $G(\alpha)$ is another function of α.

A similar method is also applied to the case of a hexagonal lattice, yielding similar results. Finally, based on the theoretical results, the author proposes an empirical formula

$$\psi_p = 48\lambda^3(1 - \lambda^5)/[9(1 - \lambda)(1 - \lambda^5) - 5(1 - \lambda^3)^2]$$

with $\alpha = 1 - \lambda^3$, which is in fair agreement with the empirical formulas proposed by Kozeny and others. Isao Imai, Japan

Compressible Flow, Gas Dynamics

(See also Revs. 1303, 1341)

1316. **A. H. Taub, On Hamilton's principle for perfect compressible fluids,** Proc. Symp. appl. Math. 1, 148–157 (1949).

The author seeks a variational principle which will yield both the differential equations and the shock-transfer conditions for a gas flow in which viscosity and heat conduction are neglected. For this purpose, he selects as the integral to be varied the difference between the kinetic energy and the total free energy, integrated with respect to time. Density variations are required to leave the mass unchanged, and temperature variations are restricted in a rather special way in order to obtain the energy conservation condition at a shock. The author obtains all the necessary equations, but only subject to the restriction to flows without heat conduction. L. Lichtenstenstein [*Grundlagen der Hydromechanik*, Berlin (1929), chap. 9, §§ 1–2] and F. H. van den Dungen [Colloques Int. Centre Nat. Rech. Sci. no. 14, pp. 88–95 (1949)] (who does not consider discontinuities) obtain variational principles yielding the momentum equation only, but valid in more general circumstances. C. A. Truesdell, USA

1317. **R. C. Prim, A note on the substitution principle for steady gas flow,** J. appl. Phys. 20, 448–450 (May 1959).

The substitution principle established by Munk and Prim [Proc. Nat. Acad. Sci. 33, 137–141 (1947)] for flows of a gas having a constant specific heat is extended to the wider class of fluids having a state equation of the form $\rho = P(p)S(s)$, where ρ denotes the density, s the specific entropy, and p the pressure. The equations of motion for this class of fluids are reduced to a canonical form previously formulated by Munk and Prim [J. appl. Phys. 19, p. 957 (1948)] involving only the reduced velocity and the pressure. It is shown that explicit elimination of the pressure from these equations is possible only for those fluids whose state equation has the form $\rho = p^kS(s)$ with $k < 1$. Relations between the Mach number and stagnation pressure and the reduced velocity field are discussed for the class of fluids under investigation. Nicholas di Pinto, USA

1318. **H. Ertel and H. Köhler, A theorem on the motion of eddies in compressible fluid** (in German), Z. angew. Math. Mech. 29, 109–113 (April 1949).

Consider in a fluid where the pressure is a function of the density only, a unit cell formed by the intersection of a streamline unit tube and a vortex unit tube. This cell is bounded by pairs of integral surfaces of the equations for the streamlines and vortex lines, respectively, and a pair of surfaces where the total energy (external potential forces included) is constant. It is shown that the mass contained in the unit cell is equal to the product of the mass flow through the streamline tube and the vorticity of the vortex tube. R. Timman, Holland

1319. **A. A. Nikolskiĭ and G. I. Taganov, Gas motion in a local supersonic region and conditions of potential-flow breakdown,** Nat. adv. Comm. Aero. tech. Memo. no. 1213, 35 pp. (May 1949) (transl. from Prikl. Mat. Mekh.).

It is shown that in general a local supersonic flow region is ter-

minated by a shock wave. For a convex profile the breakdown of the potential flow, as the free-stream Mach number is increased, is never due to the formation of an envelope of the characteristics or a limit line within the local supersonic flow region. It is also shown that the formation of the shock wave within or on the boundary of the supersonic region, cannot be preceded by the occurrence of an infinite acceleration within the interior regions of the local supersonic flow on any ordinary profile not having an infinite curvature.

The numerical work of Ringleb, previously analyzed by von Kármán to show the effect of an infinite acceleration, is reexamined to show that the infinite acceleration found in the hodograph plane actually corresponds to an infinite curvature of the streamlines in the physical plane, and therefore does not correspond to any ordinary smooth profile. This analysis of the distortion of the streamlines shows there is no valid reason for expecting a discontinuity or limit line within the interior points of a local supersonic flow region.

The work of Kaplan [same source, Rep. no. 768; Rev. 1, **1150**] is analyzed to show that the conditions requiring a shock wave have already been established before reaching the free-stream Mach number indicating the breakdown of potential flow. It may be that the indicated breakdown in the potential flow from the divergence of Kaplan's power-series representation has no physical significance.

The new criterion established for the breakdown of potential flow is that the transition line from supersonic to subsonic flow must have a monotonic variation in the angle of incidence of its velocity vector (in which case it is a sonic line); otherwise it is a line of discontinuity or shock wave. It is also proved that along any straight segment of the profile in the local supersonic-flow region the velocity must monotonically decrease. It is then easily shown that any straight segment on the profile in the local supersonic-flow region will produce a breakdown in the potential flow. This indicates the flow is unstable for any convex contour changes and generally will end in a shock wave (due to the finite thickness of the boundary layer). E. V. Laitone, USA

1320. J. S. Isenberg, The method of characteristics in compressible flow. Part IB (Numerical examples), Hdqtrs. Air Mat. Comm. Dayton tech. Rep. no. F-TF-1173C-ND, 63 pp. (1947).

Practical considerations are discussed for the application of the method of characteristics to problems in steady, supersonic gas flow, using procedures described in part I of the report (Rev. 2, **214**). Several new procedures are described.

Numerical examples from the literature are reviewed and results presented in the form of surface pressure and velocity distributions or flow nets. Some comparisons with experiment are given. The configurations considered include the German A4 body, cone-cylinder bodies, and open-nosed bodies of revolution, all at zero yaw.

Worked examples include a double-cone body of 15 deg included nose angle and 26.8% thickness in zero-yaw flow at M (Mach number) = 1.587, a body of revolution of 13.5% thickness with cuspidal tips fore and aft in zero-yaw flow at $M = 1.414$, and a two-dimensional nozzle with uniform exit flow at $M = 1.5$ and entrance flow at $M = 1.15$.

It is found that vorticity may be neglected for $M = 4$ or less with bodies having included nose angles of 30 deg or less, without appreciable effect on calculated surface velocity and pressure distributions. The vorticity cannot be neglected in the case of open-nosed bodies or where shock intersections occur. Various calculation procedures and mesh sizes are compared, and precision is discussed.

The new calculation procedures described include a method for axially symmetric flow with vorticity, a method for determination of attached shock-wave shape, and a method for calculation of two-dimensional nozzles with uniform exit flow.

William G. Cornell, USA

1321. Antonio Ferri, The method of characteristics for the determination of supersonic flow over bodies of revolution at small angles of attack, Nat. adv. Comm. Aero. tech. Note no. 1809, 53 pp. (Feb. 1949).

The theory and two numerical methods for the computation of the flow over a body of revolution at small angles of attack are presented. The method of characteristics is used with full consideration of the variations in the shock intensities. The entropy changes due to these shock variations enter the theory by an application of Crocco's theorem. In an appendix the author investigates the problem previously treated by A. Stone [J. Math. Phys. 27 (1948)], that of a circular cone at small angle of attack. Wallace D. Hayes, USA

1322. M. Holt, Flow patterns and the method of characteristics near a sonic line, Quart. J. Mech. appl. Math. 2, 246–256 (June 1949).

The author studies the geometry of the flow pattern of a two-dimensional irrotational flow near the sonic line, where weak discontinuities in the supersonic field are excluded by assuming that the velocity components are analytic functions of the coordinates. Expressions are presented for the curvature of the sonic and Mach lines at a point on the sonic line. These expressions are obtained in terms of the coefficients of a Taylor expansion for the velocity components about the same point. Also the equations for the equipotential and the isocline, valid near the series origin, are given.

Two procedures are discussed for continuing a flow into the supersonic region to a high enough Mach number to allow application of the method of characteristics. For each procedure, relations are given (in terms of the coefficients of the Taylor expansion) which permit the velocity components to be evaluated along a new initial line which may be chosen to be an isobar. Two methods using other series expansions are also presented for locating the sonic boundary of a supersonic field. The modifications of the various relations for flows with axial symmetry are discussed. Joseph Sternberg, USA

1323. H. Wendt, The Jansen-Rayleigh approximation for the calculation of subsonic flows (in German), S.-B. Heidelberger Akad. Wiss. Math.-Nat. Kl. 1948, no. 7, 26 pp. (1948).

The well-known method of approximation by expansion in powers of M^2 where M denotes the stream Mach number is treated by use of complex variables. As an example, the symmetric flow past a circular cylinder between parallel channel walls is calculated in the first approximation, i.e., including the terms in M^2. W. R. Sears, USA

1324. F. E. Ehlers, Methods of linearization in compressible flow. Part II—Hodograph method, Hdqtrs. Air Mat. Comm. Dayton tech. Rep. no. F-TR-1180B-ND, 255 pp. (Feb. 1948).

[For part I see Rev. 2, **91**.] This monograph presents comprehensively the present state of knowledge on the hodograph method in compressible flow. The authors whose methods are presented include Chaplygin, Lighthill, Tsien and Kuo, Cherry, Manwell, Nekrasov, Bergman, and Bers and Gelbart. The various approximations used, such as those leading to the Tricomi equation, are discussed and the various methods are compared where this is feasible.

An extensive bibliography is included, together with an appendix listing the many special functions appearing in the various theories, their main properties, and the location in the literature of tables containing them. Wallace D. Hayes, USA

1325. **F. E. Ehlers, Methods of linearization in compressible flow. Part III: Prandtl-Glauert method,** Hdqtrs. Air Mat. Comm. Dayton tech. Rep. no. F-TR-1180C-ND, 141 pp. (1949).

This report is a monograph covering the general application of the Prandtl-Glauert type of linearization in subsonic and supersonic flows.

Treated in detail are methods for general three-dimensional flows, the special methods available for two-dimensional, axisymmetric and conical flows, and applications to various bodies. Similarity rules and wind-tunnel corrections are given. Among the methods described are those due to Hadamard, Riemann, Hantsche and Wendt, and G. N. Ward.

Wallace D. Hayes, USA

1326. **A. D. Young and S. Kirkby, Application of the linear perturbation theory to compressible flow about bodies of revolution,** Coll. Aero. Cranfield Rep. no. 11, 14 pp. (Sept. 1947).

This paper presents the correct application of the Prandtl-Glauert method to three-dimensional bodies, having been written at a time when this possibility was still quite generally in doubt. Specific application is made to a family of streamline bodies and to spheroids, and the conclusion is made that the blockage factor for wind-tunnel interference grows as $(1 - M^2)^{-2}$ in compressible flow. Wallace D. Hayes, USA

1327. **Pierre Carrière, Slightly varied supersonic flows** (in French), C. R. Acad. Sci. Paris 228, 1632–1634 (May 23, 1949).

Starting from a given two-dimensional stationary irrotational supersonic motion with potential Φ_0 (x, y), a slightly varied motion is considered with potential $\Phi = \Phi_0 + \beta\epsilon$ (x, y), with β infinitely small. The method can also be applied to an axially symmetric field Φ_0, with disturbance either axially symmetric or dependent on the meridian angle ω in such a way that $\Phi = \Phi_0 + \beta \cos \omega \cdot \epsilon$ (x, y). Substitution of the expression for Φ into the potential equation for compressible flow, with neglect of β^2, gives a linear equation for ϵ. Introducing coordinates ξ, η parallel and perpendicular to the velocity of the original field Φ_0 at some given point P, this equation can be written: $-\epsilon_{\xi\xi} \cot^2 \alpha + \epsilon_{\eta\eta} + N = 0$, where α is the Mach angle in P, while N is an expression containing the first derivatives of ϵ (and possibly ϵ itself). The characteristics of the equation for ϵ are the same as those of the original field.

Expressions are given for the change of the epicycloidal coordinates in the hodograph plane corresponding to the disturbance described by $\beta \cdot \epsilon$. It is indicated in which way the equation can be solved by a step-by-step method. Various cases can be distinguished according to the forms of the boundary conditions. From the 6 cases enumerated we mention: body of revolution at a small angle of incidence, and influence of boundary-layer thickness on the flow. J. M. Burgers, Holland

1328. **Robert V. Hess, Study of unsteady flow disturbances of large and small amplitudes moving through supersonic or subsonic steady flows,** Nat. adv. Comm. Aero. tech. Note no. 1878, 99 pp. (May 1949).

The author extends unsteady one-dimensional flow analysis by setting up computational forms to treat the interaction of strong shocks and contact surfaces. The paper is a continuation of the work of G. Guderley [same source, tech. Memo. no. 1196; Rev. 2, 1427] and includes a calculation of the flow pattern generated by a diaphragm bursting into a vacuum at the throat of a nozzle. The formulas can be applied to the approximate calculation of flows with continuous heat addition over a large space.

In the last section relationships are established for the conservation with time of mass, energy, potential, and pulse area. For the case of small disturbances superimposed on a steady flow in a pipe of variable cross section, the growth and reflection of the disturbance properties are separated and expressed as a function of steady-flow Mach number. The calculation shows that the reflections of mass, energy, and pulse area of small disturbances are practically negligible for a range of steady-flow Mach numbers from 1 to $5^{1/2}$ in air. Henry L. Alden, USA

1329. **F. I. Frankl, Effect of the acceleration of elongated bodies of revolution upon the resistance in a compressible flow,** Nat. adv. Comm. Aero. tech. Memo. no. 1230, 8 pp. (May 1949) [transl. from Prikl. Mat. Mekh. 10, no. 4 (1946)].

The flow over a slender axisymmetric body which moves with a variable speed is considered by means of a linearized theory. If one chooses a system of coordinates which is at rest relative to the surrounding air, then the differential equation of the flow is simply the wave equation. The flow potential is then expressed by sources distributed along the axis of the body. The strength of the sources is determined from an integral equation which expresses the conditions at the surface of the body. For very slender bodies the solution assumes the same form as given formerly by von Kármán for the case of uniform motion. That this solution fulfills the integral equation in the limiting case that the fineness ratio of the body tends to zero is shown in detail. For the case of a supersonic flow a formula for the additional pressures caused by the acceleration has been given. An example shows that the influence of accelerations usually encountered under practical conditions is negligible. The paper speaks at some places of "velocities comparable to the velocity of sound," and thus suggests that these results are valid also in the transonic region. The reviewer does not feel that the short discussion offered in the present paper can be considered a proof of this conclusion. Gottfried Guderley, USA

1330. **Kl. Oswatitsch, The shock wave in stationary flow around flat profiles** (in German), Z. angew. Math. Mech. 29, 129–141 (May 1949).

Essentially, the paper does not supply any new results in the supersonic range. It represents a certain systematic arrangement of the shock problems and phenomena closely connected with shocks. From this standpoint the paper may be considered valuable. The author pays particular attention to the phenomena occurring far from a body. To represent a shock pattern in that region it is enough to assume, e.g., a flow around a triangular profile. This is so because a continuous expansion around curved profiles produces at a distance a pattern almost identical with that of an expansion around a corner (Prandtl-Meyer).

It follows, from considerations taking into account the entropy change across a shock, that the line integral of the perturbation velocity far from the body assumes a constant value. Thus, the positive and negative areas under the curve representing the perturbation velocity distribution along the arc of the profile are not equal any more (as is the case in the subsonic and supersonic linearized flow). Although the entropy change across the shock is small, the integration of that change along long shock fronts results in a finite value, which leads to the known drag in supersonic range. The variation of entropy has little effect on the vorticity of the flow. The equation for the pressure variation as a function of the entropy change is represented by means of an

expansion. The obtained results fail at the sonic velocity, and some considerations concerning this part of flow close the paper.
M. Z. Krzywoblocki, USA

1331. B. M. Kiselev, Calculation of one-dimensional gas flow, Hdqtrs. Air Mat. Comm. Dayton (transl. from Russian), tech. Rep. no. F-TS-1209-1A, 25 pp. (Jan. 1949).
See Rev. 1, 681.

1332. S. S. Penner, Flow through a rocket nozzle with and without vibrational equilibrium, J. appl. Phys. 20, 445–447 (May 1949).

The effects of the absence or presence of full vibrational equilibrium in the gases flowing through a rocket nozzle are discussed. The magnitude of these effects is found to depend not only on the nature of the gases but also on the occurrence or nonoccurrence of chemical reactions during flow. Wallace D. Hayes, USA

1333. Börje Langefors, Flow of gas through two orifices (in Swedish), Tekn. Tidskr. 79, 339–404 (May 21, 1949).

The author considers the stationary flow of a perfect gas through two orifices, one after the other. The flow quantity has been calculated as a function of the pressure ratio and the ratio of areas of the two orifices. Curves are plotted for $\kappa = c_p/c_v = 1.4$ to give the connections of the variable quantities, and comparisons have been made with the experimental results of K. Falls and W. Frössel. P. N. Brandt-Møller, Denmark

1334. G. A. Bugaenko, Concerning gas flow around an infinite lattice by the Chaplygin approximation (in Russian), Prikl. Mat. Mekh. 13, no. 4, 449–456 (1949).

Using the method developed by Levi-Civita for incompressible flows, the author computes a two-dimensional potential gas flow with separation past a lattice of straight, infinitely thin profiles, assuming for the gas Chaplygin's simplified pressure-density relation ($\gamma = -1$). L. Bers, USA

1335. Arthur E. Bonney, Engineering supersonic aerodynamics, New York, Toronto, London; McGraw-Hill Book Company, Inc., 1950, xi + 264 pp., 180 figs. Cloth, 9.3 × 6.2 in., $4.

The book, as the author states in the preface, is not meant to be a complete treatise on supersonic aerodynamics, but to supply aeronautical engineers with the basic information on the subject of supersonic aerodynamics, with special reference to technical applications and particularly to aircraft designing. Therefore the author purposely avoids advanced analytical exposition. Of the results obtained by theory, he gives an explanation rather from the viewpoint of physics than of mathematics.

In chapter 1 the author qualitatively discusses the various kinds of shock and expansion waves created by moving bodies at supersonic speed, and their effects on pressure distribution on such bodies.

In chapter 2 he studies one-dimensional flows within nozzles and diffusers, discusses the main causes of losses in pressure ratio and the methods used in order to reduce such losses (de Laval nozzle, multiple-shock diffuser, combined de Laval–multiple-shock diffuser).

Chapter 3 deals with the "linear" theory (Ackeret theory) for determining changes in pressure in a supersonic continuous gas stream in contact with a wall, as a function of the variation of the direction θ of the flow, with respect to the free stream (which is supposed to be uniform). Chapter 3 then reports the results of the Busemann theory, which uses the third-order terms in θ for determining the pressure, and also reports the results of the "exact" (as far as the flow can be considered as irrotational) Prandtl-Busemann theory, such as can be deduced through the method of "characteristics" and shock-wave theory.

The aerodynamic characteristics of the wings are studied in chapter 4. First of all the second-order approximation theory gives the aerodynamic characteristics (lift coefficient, drag coefficient, moment coefficient, center-of-pressure) of the airfoils as a function of the incidence and Mach number for the various shapes; the author also gives the "optimum" shape for an airfoil for a given maximum thickness, or for a given allowable stress (for a solid cross section). Sweepback of wings of infinite aspect ratio is considered next, according to the Busemann theory.

In the second part of chapter 4, the author studies the wings of finite aspect ratio and various plan forms (such as: rectangular wing, trapezoidal wing, delta wing, arrow wing and diamond wing); in some cases (supersonic or subsonic leading edge, supersonic or subsonic trailing edge) the aerodynamic characteristics of the wings are indicated, as well as the spanwise pressure distribution.

The last part of chapter 4 studies downwash distribution behind wings of various plan forms.

Chapter 5 examines the aerodynamic characteristics of the bodies of revolution, both in the case of conical or ogival noses, and in the case of ducted cones and ogives.

Chapter 6 describes the main types of supersonic wind tunnels with a short critical examination of their characteristics. It also gives instructions as to the measuring techniques in use and optical methods (shadowgraph, Schlieren method, interferometer) used for determining the density fields; some considerations are added concerning the effects of walls and the power required for wind tunnels.

The last chapter gives an account on the main types of supersonic aircraft and examines the effects of interference among the various parts, in a synthetic manner, as well as the use of diagrams of the aircraft characteristics. Some consideration is also given to the means of propulsion commonly employed at supersonic speeds (rocket, ramjet, turbojet) and to the performance resulting from the combined characteristics of the aircraft and means of propulsion.

The author shows great care in reporting the results of the most recent work, particularly in chapter 4 which is devoted to the various types of airfoils and wings. The part concerning bodies of revolution is less satisfactory from the standpoint of information. No discussion can be found of unsteady motion. Even with these omissions the book is fully adequate for its purpose. Carlo Ferrari, Italy

1336. Robert O. Piland, Summary of the theoretical lift, damping-in-roll, and center-of-pressure characteristics of various wing plan forms at supersonic speeds, Nat. adv. Comm. Aero. tech. Note no. 1977, 52 pp. (Oct. 1949).

Data have been collected on theoretical lift, damping-in-roll, and center-of-pressure characteristics for a group of plan forms at supersonic speeds. The forms include rectangular, triangular, unswept tapered, and arrow types; and the information is presented in the form of both curves and equations. The effects of taper ratio, aspect ratio, and sweep angles are discussed. Ed.

1337. G. N. Ward, Calculation of downwash behind a supersonic wing, Aero. Quart. 1, 35–38 (May 1949).

If the pressure distribution over a wing of infinitesimal thickness, having a small finite incidence to the stream and lying very nearly in the plane $z = 0$ is given, the values of the potential function of the fluid motion around the wing are known in the whole plane $z = 0$. Therefore the potential function and its

derivatives in the whole space can be easily obtained by well-known mathematical formulas. As an example, a computation of the downwash of a symmetric flat delta wing in the line of symmetry $z = 0$, $y \neq 0$ is presented.

Irma Flügge-Lotz, USA

1338. **Frank R. Caldwell, F. W. Ruegg, and Lief O. Olsen, Combustion in moving air,** Soc. auto. Engrs. quart. Trans. 3, 327–340 (Apr. 1949). (Suppl. to Rev. 2, **1538.**)

This paper is a general review of some combustion problems and includes some results of work done at the National Bureau of Standards and elsewhere.

Reports are given of some experiments with a 4-ft-square combustion chamber, using a homogenous mixture of propane and air with different flame holders in order to determine the rich limit on the range at air-fuel ratio. Attention is given to the mechanism of flame propagation in a stream of combustible mixture with a velocity exceeding the transition velocity of the flame. It has been shown that the degree of turbulence in the flowing mixture has little effect on either the combustion limit or flame front.

Some results are also reported of tests with a combustion chamber with a heterogeneous mixture, which tests give the influence of inlet air temperature on the combustion limits for petroleum-ether and air and the combustion efficiency, when burning industrial naphtha, as function of inlet Mach number. For constant inlet temperature it is shown that the combustion efficiency increases with increasing inlet velocity until a maximum. An interesting result is that the burner length has considerable effect on both the combustion stability and combustion efficiency.

S. Edling, Sweden

1339. **S. F. Boys and J. Corner, The structure of the reaction zone in a flame,** Proc. roy. Soc. Lond. Ser. A, 197, 90–106 (May 11, 1949).

The structure of one-dimensional flames is shown to be completely determined by constants such as those of heat conductivity, of diffusion, and of the homogeneous reaction rates. The mathematical problem in the most general case is intractable, but three simple cases are solved fully by a mathematical method of successive approximations. The three cases are those in which diffusion is neglected compared with heat conductivity, and in which reaction velocities of the following types are considered: unimolecular, bimolecular, and the quasibimolecular form of a unimolecular reaction at low pressures. The method of mathematical approximation is shown to involve errors of the order of only 10% in some actual cases, an error which is negligible compared with other uncertainties of the problem. In these simple cases it is possible to solve all details of the structure, such as the variation of composition and temperature through the flame. In assuming that diffusion is negligible compared with thermal conductivity, the authors make an assumption which is contrary to the conclusions arrived at in other recent investigations of the mechanism of flame propagation [C. Tanford and R. N. Pease, J. Chem. Phys. 15, p. 431 (1947); C. Tanford, J. Chem. Phys. 15, p. 433 (1947)].

J. Howard Charles, USA

1340. **W. B. Cybulski, W. Payman, and D. W. Woodhead, Explosion waves and shock waves. VII. The velocity of detonation in cast T.N.T.,** Proc. roy. Soc. Lond. Ser. A, 197, 51–72 (May 11, 1949).

This part of the series of papers on explosion waves and shock waves is devoted to the precise determination of velocities of detonation in cylinders of cast TNT by means of the Burxton rotating-mirror camera. The effects on the velocity of detonation of the following variables have been studied in so far as each can be independently varied: (a) the purity and crystal size, (b) the diameter of the charge, and (c) the degree of confinement of the charge.

The experimental results established are: (A) The velocity of detonation increases with the degree of purity and with increasingly fine crystal structure of the charge. (B) The velocity of detonation increases with the diameter of the charge. The important observation in this connection is that there exist a boundary diameter below which no detonation is possible and a limiting one when the velocity reaches the maximum value. These characteristics, in turn, depend upon the physical state of the explosive and the nature of confinement. (C) At diameters below the limiting value, the effect of confinement is to raise the velocity of detonation. The increment again varies with the material of the confinement. In addition, the effect of the inner diameter of the confinement and that of the orientation of the crystals of the charge are measured and discussed. All the results are tabulated and several photographs are included.

Y. H. Kuo, USA

Turbulence, Boundary Layer, etc.

(See also Revs. 1296, 1318, 1369)

1341. **Hiroshi Hatanaka, Theory of the laminar boundary layer on the surface of a body of revolution** (in Japanese), Rep. Inst. Sci. Technol. Tokyo 3, 51–53 (Mar.-Apr. 1949).

In this paper the boundary-layer equations for compressible flow along a blunt-nosed body of revolution with its axis in the direction of the undisturbed flow are reduced to those for a two-dimensional body. Thus, introducing new variables $\zeta = \int r_0^2 dx$, $\eta = r_0 y$, where x and y are distances along and perpendicular to the surface, and r_0 the distance from the axis of revolution, the author obtains

$$\partial(\rho u)/\partial\xi + \partial(\rho v_*)/\partial\eta = 0,$$

$$\rho u \partial u/\partial\xi + \rho v_* \partial u/\partial\eta = -dp/d\xi + \partial(\mu \partial u/\partial\eta)/\partial\eta,$$

$$\rho u \partial(C_p T)/\partial\xi + \rho v_* \partial(C_p T)/\partial\eta - u dp/d\xi = \partial(\lambda \partial T/\partial\eta)/\partial\eta + \mu(\partial u/\partial\eta)^2,$$

where ρ is the density, p the pressure, T the temperature, μ the viscosity, λ the conductivity, C_p the specific heat at constant pressure, (u,v) the velocity, and $v = r_0 v_* - (r_0'/r_0) yu$.

As an example of application to incompressible flow, Tani's method of obtaining the laminar separation point for a cylindrical body [J. aero. Res. Inst. Tokyo 1941, p. 199] is adapted to three-dimensional axisymmetric flow in the form that separation occurs for $\sigma = -0.084$, where $\sigma = 0.44\, r_0^{-2} u_1^{-6} (du_1/dx) \int_0^x u_1^5 r_0^2 dx$, u_1 being the velocity outside the boundary layer.

Isao Imai, Japan

1342. **G. B. Schubauer and H. K. Skramstad, Laminar boundary-layer oscillations and transition on a flat plate,** Nat. adv. Comm. Aero. Rep. no. 909 (1948).

See Rev. 1, **129.**

1343. **D. R. Hartree, The solution of the equations of the laminar boundary layer for Schubauer's observed pressure distribution for an elliptic cylinder,** Rep. Memo. aero. Res. Counc. Lond. no. 2427, 30 pp. (1949).

The solution of the equations of the laminar boundary layer has been carried out for an elliptic cylinder of thickness ratio 1/2.96, using an experimentally determined pressure distribution. For this pressure distribution, the calculations, contrary to the

observed results, do not show separation of the boundary layer. However, the calculated solution is very sensitive to the pressure distribution, and a comparatively small modification of the measured pressure distribution gives a solution which does indicate separation very close to the observed point of separation.

Some of the mathematical difficulties involved in integrating numerically the partial differential equations of the boundary layer are discussed at length, together with the methods used to overcome these difficulties. Ascher H. Shapiro, USA

1344. Milton Abramowitz, On backflow of a viscous fluid in a diverging channel, J. Math. Phys. 28, 1–21 (Apr. 1949).

Blasius attacked the problem of two-dimensional steady flow between diverging planes under nonradial initial conditions. Employing an approximate method he found that backflow will occur when $mR = 105/8$, where m is the slope of the channel, $R = Ua/\nu$ the Reynolds number, U and a the speed and section at the entrance. The result of Blasius is confirmed, and, employing his procedure, it is shown that the larger the Reynolds number, the smaller the slope of the channel and the greater the distance of the point of separation from the entrance of the channel, where however backflow cannot occur.

Giulio de Marchi, Italy

1345. E. J. Watson, Free streamline suction slots, Rep. Memo. aero. Res. Counc. Lond. no. 2177, 25 pp. (Feb. 1946, publ. 1948).

The theory of free streamlines is applied to the design of suction slots and entries to ducts. Although suction slots are intended for boundary layers where potential flow does not apply, the hope is expressed that the slot shapes derived by this procedure may provide a basis for experiment. Ed.

1346. C. C. Lin, Remarks on the spectrum of turbulence, Proc. Symp. appl. Math. 1, 81–86 (1949).

This note, written in 1947, examines the consequences of taking the Fourier transform of the dynamical equation for the propagation of the double velocity correlation in isotropic turbulence. The resulting equation for rate of change of the energy spectrum contains a term describing the nonlinear transfer of energy across the spectrum, and the author describes the explicit assumptions about this term which have been made by Obukhoff, Onsager, Weizsäcker and Heisenberg. It is shown that the first term in the expansion of the (three-dimensional) spectrum function as a power series in the wave-number is constant during decay. (Reviewer's remark: This result, although not the proof, remains true when the small wave-number components of the turbulence are anisotropic, as is usually the case in turbulence behind grids in a wind tunnel.) The last section of the paper considers the expression for the expected number of points at which one component of the velocity is zero over a given interval of a straight line. G. K. Batchelor, England

1347. J. Kampé de Fériet, The spectral tensor of homogeneous nonisotropic turbulence in an incompressible fluid (in French), Proc. seventh int. Congr. appl. Mech., 6–26 (Sept. 1948).

This paper consists for the most part of an exposition of the kinematics of turbulence in terms of a spectral tensor whose components are complex functions of the vector frequency. The turbulence itself is described in terms of a random vector field homogeneous in space but not necessarily isotropic.

The relation between the correlation tensor R and the spectral tensor ϕ is given by a Fourier-Stieltjes integral as follows:

$$R_{j,k}(h) = \int_{\Lambda} e^{i(\lambda_1 h_1 + \lambda_2 h_2 + \lambda_3 h_3)} \phi_{j,k}(\lambda) d\lambda_1 d\lambda_2 d\lambda_3.$$

The author states that he has proved that the necessary and sufficient condition that the nine functions $R_{j,k}(h)$ be the components of the correlation tensor of a stationary statistically continuous random vector field with continuous spectrum, is that the components $\phi_{j,k}(\lambda)$ be the coefficients of a nonnegative definite Hermitian form,

$$\Phi = \sum_{j,k} X_j X^*_k \phi_{j,k}(\lambda) \geq 0,$$

where X_1, X_2, X_3 are arbitrary complex constants, and the asterisk denotes the complex conjugate.

For an incompressible fluid the author shows that the spectral tensor can be written as

$$\phi_{j,k}(\lambda) = f_j(\lambda) f_k^*(\lambda) + (\delta_{j,k} - \lambda_j \lambda_k/\mu^2) g(\lambda)$$

where $f(\lambda)$ is a complex vector orthogonal to the vector frequency λ, $g(\lambda)$ is a real positive function, and δ is the unit tensor.

The author then shows that the spectral tensor Ψ of the vorticity in an incompressible fluid is related to the spectral tensor ϕ of the velocity by the equation $\Psi = \mu^2 \phi$, where u is the modulus of the frequency vector, i.e., $\mu^2 = \lambda_1^2 + \lambda_2^2 + \lambda^2_3$.

In addition to these kinematic results the author sketches very briefly the application of his results to turbulence which satisfies the Navier-Stokes equations. As indicated in other papers, the author has some doubts as to the applicability of the Navier-Stokes equations to the turbulent motion of fluids.

Hugh L. Dryden, USA

1348. S. Chandrasekhar, On the decay of isotropic turbulence, Phys. Rev. 75, 1454–1455 (May 1, 1949).

The spectrum of turbulence has been obtained following Heisenberg's assumption for the transfer of energy. It is shown that the solution leads to a cutoff of the spectrum at high frequencies instead of the inverse seventh-power law stated by Heisenberg. C. C. Lin, USA

1349. A. A. Townsend, Momentum and energy diffusion in the turbulent wake of a cylinder, Proc. roy. Soc. Lond. Ser. A, 197, 124–140 (May 11, 1949).

The author has studied in considerable detail the turbulent motion in the wake of a circular cylinder at distances of 80, 120, and 160 diameters downstream from the cylinder in an air stream of turbulence of approximately 0.13%. The cylinder was 0.953 cm in diameter, the mean speed 1280 cm/sec, and hence the Reynolds number was about 8000. The hot-wire anemometer techniques developed at Cambridge were applied to measure turbulent intensities, mean squares of the velocity derivatives, mean values of the double and triple velocity products, skewness and flattening factors, and the downstream scales of the turbulence.

The dimensionless functions describing the wake structure are not independent of distance from the cylinder and hence the wake has not reached the dynamic equilibrium required by the similarity hypothesis. Oscillograph records show that, except close to the wake center, the flow at any point is fully turbulent only for a fraction of the total time of observation, and this fraction decreases with distance from the wake center. These records and the results of the measurements suggest that the wake consists of a small fully turbulent core surrounded by a region of intermittent turbulence due to jets or billows of turbulent fluid from the core. In other words, the instantaneous outer boundary of the wake is not a smooth surface of revolution but exhibits excrescences whose height and spacing are of the same order as the wake diameter. Such a structure has also been indicated in previous work on other systems of turbulent shear flow with a free boundary such as jets and boundary layers.

The author interprets his measurements as indicating that turbulent transfer of momentum is associated with the turbulent motion within the core and within the jets, whereas diffusion of turbulent energy and heat is associated with the bulk movement of the jets. He regards the jets as initiated by local fluctuations of pressure within the core.

Another proposed description is that the wake structure is related to a source of energy of nearly fixed wave number. Nonlinear terms produce intermodulation of frequencies within the narrow frequency band, the difference wave numbers producing the large eddies or jets, and the summation wave numbers the turbulence within the core and jets. Hugh L. Dryden, USA

Aerodynamics of Flight; Wind Forces

(See also Revs. 1230, 1312, 1313, 1314, 1335, 1336, 1357, 1358)

1350. G. W. Trevelyan and D. R. Blundell, Determination of drag of jet-propelled aircraft in flight, Aero. Quart. 1, 89-100 (May 1949).

The method described in this paper consists of decelerating at minimum rpm and constant altitude, and calculating the drag from the measured deceleration. By this procedure the thrust term becomes relatively unimportant in the equation of motion, and systematic errors in the estimate of engine performance have only a small effect on the accuracy of the results.

Joseph V. Foa, USA

1351. Angelo Miele, Calculation of the horizontal velocity of jet airplanes in incompressible and compressible flows (in Italian), Riv. aero. 25, no. 9, 557–570 (1949).

1352. E. C. Pike, Note on propeller-turbine reduction methods, Aero. Quart. 1, 77–88 (May 1949).

This paper deals with the problem of reduction of flight-test data of the performance of propeller-turbine engine to a common basis for purposes of comparison and evaluation of merit. The "notes" are discussed from a very practical standpoint, considering at the outset the variables which aircraft companies can most readily obtain from flight tests, and then discussing the most practical method for reducing the data to dimensionless corporative bases. Two principal methods are discussed, the first being a graphical "nondimensional" method and the second a purely analytical procedure. The paper proceeds to illustrate that the graphical method is much simpler than the analytical, provided enough flying can be carried out to cover the effects of the important variables of engine speed, flight velocity, and a "third variable" covering distribution of power between the propeller and the jet thrust. The analytical method is feasible, but is hampered by a lack of generalized information on the variation of certain of the important parameters with the aforementioned variables. This paper should be read particularly by all persons engaged in the handling and reduction of flight-test data from propeller-turbine engines; likewise engineers engaged in analysis of data for any type of jet engine may find ideas presented useful to their work. E. Arthur Bonney, USA

1353. K. Mitchell, Estimation of the effect of a parameter change on the roots of stability equations, Aero. Quart. 1, 39–58 (May 1949).

This paper presents mathematical expressions for the partial derivatives giving the rate of change of the roots with respect to a parameter upon which the coefficients of a quartic equation may depend. Specific application is made to the characteristic equation of the lateral motions of an airplane. The expressions derived serve two purposes:

(1) If changes in the individual stability derivatives equal to the probable error in their estimation or measurement are assumed, then the method given enables an investigator to rapidly compute the probable error in the roots of the stability quartic due to the uncertainty in the derivatives.

(2) An airplane designer may calculate the effect on the stability quartic roots of a proposed design change without the labor of recomputing the coefficients and solving the quartic. Explicit expressions for the changes in the coefficients are, however, derived and tabulated.

Numerical examples were computed and one is presented. Unfortunately the method did not prove to be accurate for computing the effects of changes in directional stability.

Extensive calculations, to determine which derivatives, when changed or incorrectly estimated, have the greatest effect on the stability roots, confirm the known results arrived at by less elegant mathematical procedures. Dunstan Graham, USA

1354. Gilbert A. Haines, Comparison of pitching moments obtained during seaplane landings with values predicted by hydrodynamic impact theory, Nat. adv. Comm. Aero. tech. Note no. 1881, 25 pp. (May 1949).

Pitching moments and center-of-pressure locations obtained from a landing investigation in smooth water of a conventional flying boat have been compared with the values predicted by general hydrodynamic impact theory to determine the applicability of the theory to actual seaplane landings. Landings were generally moderate and covered as wide a range of trim and velocities as practical.

The experimental center-of-pressure location was in reasonable agreement with the theoretical value of approximately one-third the wetted keel length forward of the step.

The experimental pitching moments for impacts in which only the V-shaped part of the hull was immersed were in reasonable agreement with theoretical values. For impacts in which the chine flare was immersed, the experimental pitching moments were greater than the theoretical values. Diving rotation decreased the experimental pitching moment during the early part of the impact when the center of pressure was aft of the center of gravity, and increased the pitching moment when the center of pressure was forward of the center of gravity.

Ernest G. Stout, USA

Aeroelasticity (Flutter, Divergence, etc.)

1355. J. H. Greidanus and A. I. van de Vooren, Mathematical principles of flutter analysis, Nat. LuchtLab. Amsterdam Rep. no. F. 43, 80 pp. (Jan. 1949).

This is a comprehensive survey from an advanced standpoint of the mathematical principles of flutter analysis regarded as an extension of the theory of small oscillations to nonself-adjoint systems. The aerodynamic forces and moments, which introduce the nonself-adjointness because of their asymmetry, are taken to be those corresponding to two-dimensional, incompressible, potential flow. The partial differential equations for an unswept wing-aileron-rigid-fuselage system are established and immediately converted to integral equations. Approximation methods of solution of these equations are discussed in great detail. The authors state that while the nonself-adjointness of the flutter equations does not affect the routine computation schemes of flutter analysis, this complication is important in the development of advanced methods of analysis and in the theoretical consideration of the accuracy of approximation methods.

Two slight errors in the report might be pointed out. The authors state that the Lagrangian generalized forces Q_i cannot be established for the aerodynamic forces and moments. In this reviewer's opinion, the virtual work done by all the aerodynamic forces during an arbitrary variation of one coordinate, say δq_i, with all other coordinates fixed, has meaning. Furthermore, this procedure yields the same results as are obtained by setting up the governing partial differential equations on the basis of dynamic equilibrium, and by then introducing generalized coordinates. Secondly, the authors state that the use of measured, still-air modes of vibration to represent the flutter modes is seldom made, allegedly because of the additional numerical work. However, this procedure is frequently applied in American factories, with the numerical work considered to be not excessive.

Paul A. Libby, USA

1356. M. D. Haskind and S. V. Falkovich, Vibration of a wing of finite span in a supersonic flow, Nat. adv. Comm. Aero. tech. Memo. no. 1257, 11 pp. (Apr. 1950).

See Rev. 1, **353.**

1357. P. L. Bisgood and D. J. Lyons, Preliminary report on the flight measurement of aero-elastic distortion in relation to its effects on the control and longitudinal stability of a Mosquito aircraft, Rep. Memo. aero. Res. Counc. Lond. no. 2371, 39 pp. (1949).

This paper is the latest in a title-source series reporting results of an investigation intended to relate the changes in static longitudinal stability and control parameters occurring at high speeds to the effects of compressibility and aeroelastic distortion. Whereas the previous papers have dealt mostly with the theoreti cal aspects of the problem, this report is concerned with the correlation between the distortions and the parameter changes as measured in flight tests. It is an interim report, however, intended primarily to set down experimental methods rather than results. Only a sampling of the data obtained is included but good correlation is indicated. A more complete analysis is intended subsequently.

Arthur L. Jones, USA

1358. Haydn Templeton, Control reversal effects on sweptback wings, Aero. Quart. 1, 3–34 (1949).

Aileron-reversal effects on sweptback wings in general and elevon-reversal effects on tailless sweptback wings in particular are discussed on a nonmathematical basis, attention being confined to the orthodox flap type of control. The main purpose of the paper is to convey in the simplest terms possible a clear physical picture of the conditions producing loss of control power, emphasis being naturally laid upon the part played by structural wing distortion. Certain qualitative features relating to the two phenomena are also discussed. As a general introduction to the discussion on aileron-reversal effects, the definition of "aileron power" in relation to the actual dynamic condition of rolling is described at some length. For elevon-reversal effects on tailless aircraft the effect of wing flexibility on both "elevon power" and on trim in steady symmetric flight is considered. (From author's summary.)

The results of certain calculations on a hypothetical wing are included. A collocation method, based on series representations of the wing distortions, for the calculation of both aileron and elevon-reversal effects is given in an appendix.

J. H. Greidanus, Holland

1359. Thomas D. Reisert, Gust-tunnel investigation of a flexible-wing model with semichord line swept back 45°, Nat. adv. Comm. Aero. tech. Note no. 1959, 13 pp. (Oct. 1949).

Results are presented of a gust-tunnel investigation to determine the amount of gust-load alleviation due to wing flexibility. It was indicated that while the net reduction in root-section bending moment may be appreciable, the reduction in total load would be small unless adverse pitching motion could be eliminated. Ed.

Propellers, Fans, Turbines, Pumps, etc.

(See also Revs. 1300, 1311)

1360. E. F. Fiock, Bibliography of books and published reports on gas turbines, jet propulsion, and rocket power plants, Nat. Bur. Stand. Circular no. 482, 49 pp. (Sept. 1949).

1361. G. C. I. Gardiner, Some aspects of propeller fatigue testing, Aircr. Engng. 21, 149–152 (May 1949).

The author deals with fatigue testing, especially of modern constant-speed propellers. A propeller test of 100 to 150 hr was, until recently, taken as sufficient to prove that at least the steel components have an adequate life time. But some failures of steel components even after 1000 flight hours indicate the utmost importance of vibration-stress survey in flight. The main sources of failure are not only the engine gas and inertia forces but also irregularities of the air flow through the propeller disk, having relatively low frequencies.

The main stress-carrying components are investigated systematically at the test bed. For steel components 50.10^6 cycles are required, and for aluminum, 500.10^6 cycles. The propeller blade is tested in a special fatigue-testing machine on which the blade is excited to its natural mode of vibration by means of the mechanical regeneration method. Using frequencies between 80 and 140 cps, a test of 500.10^6 cycles takes 1500 hr.

The means by which the propeller blade is retained in the hub against centrifugal force are investigated in special blade-retention rigs, the steady stress due to centrifugal force being reproduced by hydraulic rams. The vibration stresses are introduced by means of a mechanical out-of-balance vibrator.

The propeller hub is investigated in a similar manner, dummy blades representing faithfully the method of their retention in the propeller hub. Two mechanical out-of-balance exciters reproduce any combination of vibration stresses. For 50.10^6 cycles with a frequency of 60 cps the duration of the test is about 230 hr.

Amplitudes and accelerations being known at different places of the engine, a combination for testing the structure reliability of accessories is achieved by subjecting them to an amplitude of vibration commensurate with their position on the engine. For this purpose a vibratory table similar to that used on the blade test is used. Frequencies of 100 to 120 cps are obtained and vibratory acceleration of $\pm$ 80 g can be produced.

Ferd. Budinsky, Czechoslovakia

1362. J. D. van Manen, The design of propellers for tug boats (in Dutch), Schip en werf 16, no. 12, 241–248 (June 1949).

This article gives a good survey of the questions connected with the design of screws for single-screw tugboats. With the aid of the Wageningen Model Basin μ-σ propeller diagrams, the case of an 800-hp tugboat is worked out in a very complete way. The requirements for greatest speed, maximum tow-rope pull, and a compromise between these requirements are taken into account, as well as those for freedom of cavitation. Diagrams are given for the tug's own resistance, for cavitation, for wake- and thrust-deduction factors, and for estimating the tug's efficiency. The beneficial influence of the application of a Kort nozzle is discussed.

The captions to figs. 4 and 4a should be interchanged.

L. Troost, Holland

1363. **L. G. Bell, Some model experiments on the effect of blade area on propeller cavitation,** Trans. Instn. nav. Archit. Lond. 90, 79–91 (1948).

See Rev. 1, **1281.**

1364. **John T. Sinnette, Jr. and William J. Voss, Extension of useful operating range of axial-flow compressors by use of adjustable stator blades,** Nat. adv. Comm. Aero. Rep. 915, 28 pp. (1948).

Procedures of calculation are presented for the effect of changes of blade angles of stator and rotor rows, within limits of permissible Mach numbers and blade loadings, based upon the simplifying assumption that the flow in a blade row may be represented adequately by the characteristics of the section on the mean radius.

Application of the theory was made and experimental verification of its validity established, in resetting the stator blades only of the 8-stage NACA axial-flow compressor. Test results in this specific case show that considerable improvement of compressor efficiencies can be achieved at speeds appreciably below the design speed, and that peak-efficiency rates of flow can be varied up to 30% without loss of peak-efficiency pressure ratios.

J. R. Weske, USA

Flow and Flight Test Techniques

(See also Rev. 1352)

1365. **E. Roche, Measurement of air flow. Limits of utilization of German standards D. I. N. 1945** (in French), Off. nat. Étud. Rech. aéro. Rep. no. 30, 22 pp. (1949).

In this paper the author compares the results of tests on airflow measurements for an air-cooled engine, by means of the diaphragm method, with the discharge coefficients predicted on the basis of the AFNOR standardized values and those given in the German standards DIN 1945.

By using the AFNOR standardized coefficients, different curves were obtained for each orifice in a diagram plotting the rate of flow against pressure drop. The discrepancies were improved by using the standards coefficients specified in the German DIN 1945; the tests which fall within the DIN tolerance zone show satisfactory correlation. The results are in close agreement for Reynolds numbers exceeding 370,000 which is more severe than the limiting value from the DIN standards (270,000). To meet the requirement of 0.5% accuracy, the following limits are recommended by the author: the differential head at the orifice should not exceed 100 mm water, the pipe diameter should exceed 200 mm, and the orifice-area ratio should not exceed 0.22. This accuracy needs pressure readings within $^1/_{20}$ mm water which, the author believes, can be realized in an inclined-tube water manometer at 5%; the glass tube should have 4-mm ID. The paper concludes with a chart giving the correct size of orifices for any installation in accordance with two limits of utilization: a minimum discharge required by the limiting value of Re, and a maximum discharge referring to a given accuracy of more than 1%.

G. A. T. Heyndrickx, Belgium

1366. **Joseph-Maurice Bourot and Jean-Jacques Moreau, On some flow-visualization methods** (in French), C. R. Acad. Sci. Paris 228, 1628–1630 (May 23, 1949).

The region of flow visualized by means of suspended particles of lamellar shape is characterized by zones of different luminosity. The authors explain the phenomenon, for two-dimensional potential flow, through an evaluation of the statistic distribution of the normals to the lamellae, following a uniform distribution at upstream infinity. Experience confirms the calculations for the simple case of the flow about a circular cylinder.

Duilio Citrini, Italy

1367. **Joseph-Maurice Bourot, On the visualization of the tip-vortex of a wing in a wind-tunnel, using aluminum strips** (in French), C. R. Acad. Sci. Paris 228, 1567–1569 (May 16, 1949).

Flow visualization by means of intermittently illuminated aluminum flakes was used for the measurement of the velocity distribution in a trailing vortex in air at very low speed (72 cm/sec). Accurate measurements of the velocity components in a plane normal to the axis could not be made in the central region of the core (the particle path being there almost parallel to the axis), but outside of this region the results give valuable quantitative information on the structure of the Rankine combined vortex, and particularly on the transition from the rotational core to the surrounding irrotational field.

Joseph V. Foa, USA

1368. **A. A. Elkarim, New form of viscometer for transparent viscous liquids,** Rev. sci. Instrum.19, no. 12, 833–834 (1948).

This method is based on the application of Stokes' law, and its aim is to measure the coefficient of viscosity of transparent viscous liquids. The method is to allow air bubbles of maximum diameter to evolve by a manometer system from the bottom to top of a liquid placed in an adjacent adjoining glass cell.

Author's summary

Thermodynamics

(See also Revs. 1267, 1339, 1403)

1369. **E. Kirschbaum and Josef Lise, Recent results of research on evaporation phenomena** (in German), Chem. Ing. Tech. 21, no. 5/6, 89–94 (March 1949).

The paper, which is in two parts, deals with the evaporation from surfaces of both hygroscopic and nonhygroscopic materials under various conditions of air flow. The first part is devoted to an explanation of the physical processes involved and a formulation of simple theoretical relations. The second part is related to an experimental verification of the results of the first part.

It is shown that since the air dry-bulb temperature (t_a) will be greater than the surface temperature (t_s), heat, which is just sufficient to provide the necessary latent heat of evaporation (r_s) of the water, is transferred from the air to the material. If h is the heat-transfer coefficient, σ the evaporation number and x_s and x_a the moisture contents of the air at the surface and in the surrounding air respectively, then $h(t_a - t_s) = \sigma r_s(x_s - x_a)$ (1). The vapor, so formed, suffers a fall of vapor pressure in diffusing from the surface to the surrounding air, but receives an increase of temperature with a resultant rise in enthalpy. It is assumed that ultimately the vapor and air are at the same temperature.

The author proves next that if di and dx represent the increase of total heat and moisture content, respectively, of the air flowing over the surface at temperature t_s, $di/dx = t_s$ (2). This equation, which is independent of the type of heat transfer, shows that the Mollier ix-diagram of the air can be represented approximately by a straight line.

A combination of equations (1) and (2) determines a value for the parameter $h/\sigma Cp$ which can easily be evaluated for cases of either free or forced convection if the similarity laws connecting heat transfer with diffusion are assumed to hold.

A series of experiments is reported, for both laminar and turbulent air flow, on evaporation of moisture from a cylinder made of fossil meal bricks. In each case the value of the parameter $h/\sigma Cp$ was found. Fair agreement was obtained between the measured and calculated results.

G. M. Lilley, England

Heat Transfer; Diffusion

1370. G. M. Dusinberre, Numerical analysis of heat flow, New York, McGraw-Hill Book Co., Inc., 1949, xvi + 227 pp., 98 figs. Cloth, 9.2 × 6.1 in., $4.50.

This book intends to give the uninitiated reader a working knowledge of the application of numerical methods to heat flow in solids. As is appropriate in view of the nature of the subject, the presentation is almost exclusively by example.

The contents of the book can be divided into two parts of equal volume: the steady-state problems, analyzed by means of Southwell's relaxation method which Emmons has shown to be so useful in heat-transfer problems, and the transient problems, analyzed by means of the iteration method. Little is said about graphical methods (such as Schmidt's) except where they are accessory to numerical methods as in problems with variable thermal properties. A combined relaxation and iteration method is developed by the author for the analysis of problems with periodic conditions.

In each of the two parts, the presentation starts out from one-dimensional problems and proceeds to those of two or more dimensions. Among the problems used for illustration are insulated pipes, boiler tubes, heat exchangers, walls and interiors of heated buildings, welding of plates, heterogeneous systems with heat sources, walls of periodically heated structures with temperature-dependent thermal properties, and the drying process where the diffusion of moisture is considered as analogous to a heat-transfer problem. It is the merit of this book that it presents scattered information in a gradually progressing, instructive manner.

Eric F. Lype

1371. W. H. Giedt, Investigation of variation of point unit heat-transfer coefficient around a cylinder normal to an air stream, Trans. Amer. Soc. mech. Engrs. 71, 375–381 (May 1949).

Experimental data are presented showing the distribution of local heat-transfer coefficient and the pressure distribution around a cylinder normal to an air stream for a Reynolds number range of 70,800 to 219,000. Most previous analytical and experimental work on this problem treated a cylinder having an isothermal surface. The present work studies a cylinder having essentially uniform heat transfer per unit area around the cylinder. The cylindrical surface was electrically heated by a thin nichrome ribbon wound helically around it.

For values of Reynolds number below about 1.2×10^5, the local heat-transfer coefficient decreases from the stagnation point in front of the cylinder to a minimum at about 80 deg, then increases to a maximum at the 180-deg position behind the cylinder. Above this critical value of Reynolds number the curves have maximum points 0 and 180 deg and in the neighborhood of 115 deg; minimum points occur in neighborhood of 90 and 130 deg.

The pressure distribution curves have maximum points 0 and 180 deg and a minimum point in the range of 60 to 80 deg.

The critical value of Reynolds number separating the two types of local heat-transfer coefficient curves appears to correspond with the point at which the drag coefficient drops suddenly.

Warren M. Rohsenow, USA

1372. F. W. Hutchinson, Influence of gaseous radiation in panel heating, Trans. Amer. Soc. heat. vent. Engrs. 53, 285–294 (1947).

In comfort air conditioning it has been the usual practice to evaluate radiant-heat exchange on the assumption that the atmosphere is nonabsorbent. With the aid of the Stefan Boltzmann equation, an equivalent film coefficient for radiation, h_r, is obtained.

$h_r = 0.172 \times 10^{-8} (T_h^4 - T_c^4)/(t_h - t_c)$ btu/hr, sq ft, deg F.

Under representative panel-heating conditions, $h_r = 1.08$.

The author demonstrates that the combined effect of water vapor and, to a lesser extent, carbon dioxide in the atmosphere is to reduce by about 10% the heat transfer so calculated. A graphical solution is given for the equivalent radiation coefficient for humid atmospheres. In this solution an attempt is made to allow for the average length of path of the radiant beam, which becomes a factor to be considered when atmospheric absorption is recognized.

Reflecting surfaces have often been proposed as a means of reducing bodily radiant-heat loss. Due to cumulative absorption as the energy traverses and retraverses the room, this idea is shown to be quite ineffective. The lining of a room 15 ft × 15 ft × 9 ft high with material of 80% reflectivity would reduce the radiant-heat loss of an occupant only by about 2%.

Equations are presented which make possible estimates of radiant-heat exchange between certain systems of reflecting surfaces separated by an absorbing medium.

R. E. Button, Australia

Acoustics

(See also Revs. 1228, 1229, 1275, 1276, 1277)

1373. Uno Ingård, On the radiation of sound into a circular tube, Trans. Chalmers Univ. Technol. 70, 1–51 (1948).

Solutions to the wave equation in a circular tube that is excited by a radially symmetric source are obtained as expansions in the appropriate eigen functions. Particular attention is paid to the plane piston source, and rather complete results for the radiation impedance are obtained, both in the form of algebraic equations and curves. The majority of the results assume that only the dominant (plane wave) mode is transmitted, but some results are given for the case where the first higher-order mode also propagates. The application of the results to cylindrical resonators is discussed. Perhaps the most important contribution of the paper lies in the numerous experimental measurements which exhibit excellent agreement with the theoretical results. The reviewer believes that these measurements should prove both interesting and important to those working in experimental acoustics. See also Rev. 2, 137.

John W. Miles, USA

1374. R. J. Urick and W. S. Ament, The propagation of sound in composite media, J. acoust. Soc. Amer. 21, 115–119 (Mar. 1949).

The authors treat the case of the propagation of sound in a fluid medium in which are dispersed spherical particles having nonuniform particle size. The propagation constant of a composite medium of this type is derived by summing the forward and backward scattered waves from the spherical particles in order to find the relation between the transmitted and reflected waves. Thus the propagation constant can be found in terms of the scattering coefficients of a single particle (derived by Lamb) which in turn are dependent on the characteristics of the two media. The expression reduces to the propagation constant previously derived by the first of the authors for the case where all the particles are of one size. The effect of interactions between the scattered waves and neighboring particles is neglected. Experimental measurements of velocity and absorption in the frequency range from 3 to 15 mc/sec which were made on bromoform-in-water and mercury-in-water emulsions, were in agreement with theory for concentration up to about 25%.

Albert London, USA

1375. **E. N. Fox, The diffraction of two-dimensional sound pulses incident on an infinite uniform slit in a perfectly reflecting screen,** Phil. Trans. roy. Soc. Lond. Ser. A, no. 839, 242, 32 pp. (May 1949).

The general solution for this diffraction problem has been obtained, and the special case of a unit-function pulse is examined numerically. The most interesting pressure phenomena to the rear of the screen are those occurring in the direct line of the slit where the pressure front exhibits an initial peak which becomes progressively thinner as the front travels farther to the rear. Apart from this effect, the general process of ultimate pressure equalization through the slit appears to be of an asymptotic character, there being no evidence that the pressure at any point to the rear ever exceeds the incident unit pressure. The results also indicate that a region of sensibly incompressible flow is soon developed in the neighborhood of the slit, this region increasing in size with increasing time. Finally, it is found that the slit behaves, to fair accuracy, as a central two-dimensional source relatively soon after the arrival of the pressure front, for all points to the rear more distant than about $5a$ from the center of the slit, where $2a$ is the width of the slit.

This paper is a continuation of a previous paper dealing with the diffraction problem of a perfectly reflecting infinite strip [see Rev. 2, **528**]. Robert Fehr, USA

1376. **John W. Miles, Diffraction of a plane wave through a grating,** Quart. appl. Math 7, 45–64 (April 1949).

The solution is presented of the problem of diffraction of plane waves of sound energy normally incident on an infinite plane grating composed of infinitely thin coplanar equally spaced strips with parallel edges. Potential theory is applied and an integral equation for the velocity in the aperture is derived and solved. Since the potentials are set up in the form of Fourier expansions, the solutions appear as an infinite set of simultaneous equations. It is shown that if N of these equations are solved, the neglected terms are of the order $N^{-1}[(1 - 4b^2/N^2X^2)^{-1/2} - 1]$. Results are extended to electromagnetic waves. Solutions for an aperture of finite thickness are obtained in approximate form. Curves of transmission coefficient vs. aperture opening are presented for several ratios of grating space to wave length. Agreement is shown with Kirchhoff's theory for the special case of a half-open grating. Of some interest is the appearance of a sharp resonance in the latter solution. R. G. Wilson, USA

1377. **Joseph John Kyame, Wave propagation in piezoelectric crystals,** J. acoust. Soc. Amer. 21, 159–167 (May 1949).

The author considers the interaction of electromagnetic and acoustic (i.e., elastic) waves in a crystalline medium due to piezoelectric coupling. The result is a pentarefringent medium, compared with nonpiezoelectric crystals, which may be, at most, birefringent electromagnetically and trirefringent elastically. The boundary-value problems of refraction and reflection at an interface between two semi-infinite media and for a slab of finite thickness are treated. Calculations for actual materials (e.g., sphalerite) are given, and the piezoelectric coupling generally is found to be quite weak, although it may be important at resonance. John W. Miles, USA

1378. **C. Zwikker and C. W. Kosten, Sound absorbing materials,** New York, Amsterdam, London, Brussels: Elsevier Publishing Company, Inc., 1949, ix + 174 pp., 92 figs. Cloth, 10 × 6.5 in., $3.

The object of this book is to provide the theoretical foundation to the design of sound-absorbing materials, i.e., to explain the relation between the behavior of a material and a few fundamental properties. A large part of it is based on research done by the authors before and during the war.

Chapter I contains the simple theory. The authors characterize the materials by their impedance curves in the complex plane at normal incidence, from which the absorption coefficient and phase jump at reflection can be read immediately. Porous materials can be defined by their porosity, their resistance constant, and a structure constant. This last constant (normally between 3 and 7), giving the influence of the structure of the pores, can only be determined in a few idealized cases.

Chapter II gives a survey of the theory of the motion of air in narrow channels in different frequency regions. Chapter III treats the case where the compliance of the frame containing the pores is not negligible (i.e., rubber). Chapters IV and V describe methods for measuring the elementary properties and the impedance at normal incidence; experimental results of the authors and others are compared with the theoretical ones in chapter VI.

Chapter VII is a discussion of sound absorption by resonators with an application to perforated panels. Experimental results and design charts are given. Only in the last chapter VIII is other than normal incidence of waves treated.

R. Vermeulen, USA

1379. **A. W. Vogeley, Sound-level measurements of a light airplane modified to reduce noise reaching the ground,** Nat. adv. Comm. Aero. Rep. no. 926, 6 pp. (1949).

One of the primary objections to having airports near populated areas is the noise made by the aircraft. A study of the noise problems showed that the main sources of airplane noise are (1) the propeller and (2) the engine exhaust. Theory indicated that both these noise sources could be reduced to any desired level. To demonstrate this the National Advisory Committee for Aeronautics modified an army liaison airplane by changing the engine and propeller from a direct drive to a geared engine with a slow-speed propeller, and applying adequate engine muffling. The result of the modification showed that the modified airplane produced 20 db less noise than the unmodified airplane, producing only 5 db more noise than the airplane in a power-off glide at comparable speeds. It was also demonstrated that the modification was made without loss of efficiency, the pilot reporting that the performance of the modified airplane equaled or exceeded the performance of the unmodified airplane.

Arthur A. Regier, USA

Ballistics, Detonics (Explosions)

(See also Rev. 1332)

1380. **P. Matthieu, On the dynamics of rockets** (in German), Schweiz. Arch. 15, 129–137 (May 1949).

The motion of a rocket is studied under the fundamental assumptions that the trajectory is plane, and that the variations of slope of the trajectory and the angular deviations are small. If, in addition, the following quantities are assumed as constant: (a) the mass and the moment of inertia, (b) the thrust and the overturning moment, (c) the aerodynamic coefficients of drag, of static and dynamic lift, and of static and dynamic moment—then the author shows that the system of equations governing the motion can be reduced to a single linear, second-order, nonhomogeneous equation, with coefficients depending on time, which can, moreover, be solved in a simple closed form when some additional unessential approximations are performed. After the discussion of the solution and its application to a practical case, the author shows how his method can be extended to the calculation by iteration of the case when the assumptions (a), (b), (c) are no longer verified. Luigi Crocco, USA

1381. F. R. Gantmacher and L. M. Levin, Equations of motion of a rocket, Nat. adv. Comm. Aero. tech. Memo. no. 1255, 21 pp. (Apr. 1950).

See Rev. 1, **1422.**

Soil Mechanics, Seepage

(See also Revs. 1262, 1315, 1374, 1406)

1382. Hamdi Peynircioğlu, Test on bearing capacity of shallow foundations on horizontal top surfaces of sand fills and the behaviour of soils under such foundations, Proc. Sec. int. Conf. Soil Mech. Found. Engng. 3, 197–205 (June 1948).

Tests made in a sand box with glass walls were carried out to evaluate the behavior of sand fills under shallow foundation plates on their horizontal top surfaces, and to observe the mechanical effects when the sand mass is pressed to failure. The results indicate that the bearing capacity of a shallow foundation on the horizontal top surface of a sand fill can be determined by means of methods based upon plastic equilibrium. Practically in all tests the formation of the sliding wedge occurred on one side of the fill, indicating the importance of the consideration for foundation and stability computations. S. K. Ghaswala, India

1383. T. Mizuno, On the bearing power of soil in a two-dimensional problem, Proc. Sec. int. Conf. Soil Mech. Found. Engng. 3, 44–48 (June 1948).

The effect of soil weight on the ultimate bearing capacity under a uniform vertical strip load is analyzed by considering plastic equilibrium conditions in the transition zone between an active wedge under the load and a passive wedge beyond the load.

The transition zone is divided into n wedges giving $8n + 2$ simultaneous equations. By comparison with known results for the effect of surcharge and cohesion, $n = 6$ was found to be satisfactory. Presented graphically are sliding surfaces for an angle of friction of 30 deg and bearing capacity factors for angles of friction from 0 to 40 deg. Edward S. Barber, USA

1384. Richard Jelinek, Calculation of the settlement of foundations under eccentric loads (in German), Bauplan Bautech. 3, 115–121 (Apr. 1949).

The author reviews briefly the best-known theories of stress propagation, and points out all factors influencing stress concentration. Uniform stress distribution may be expected only under perfectly loose plates, whereas under an infinitely rigid body theoretically infinitely big stresses would arise under the edges. This concept leads to Froelich's "critical edge loading": $q_k = t\gamma/[\cot\varphi - (\pi/2 - \varphi)]$.

Even a small flexibility will exert a smoothing effect on stress peaks. The author considers the case of a loose fill with evenly growing height, and computes the stresses in the edge verticals according to Boussinesq's formula and, assuming a constant Young's modulus and Poisson's ratio, he computes settlement values under rectangular plates (similarly to Steinbrenner) loaded with a triangular loading surface. Values are tabulated in diagrams for various ratios of sides. Ch. Széchy, Hungary

1385. Henry B. McDonald, Nathan L. Smith, Jr., and B. Everett Beavin, Sr., Compaction of soil and base material on the Baltimore friendship international airport, Highw. Res. Bd. Bull. no. 23, 12–17 (1949).

The amount of compaction required was determined according to the results of preliminary tests on soil samples (modified Proctor tests) and a full-scale test program on the site. Compaction was obtained by a heavy sheep's foot roller (500 lb per sq in footprint pressure) and a heavy rubber-tire roller (four wheelloads of 100,000 lb). Although an ample test program was executed, it was found impracticable to translate the data into exact rules according to bad weather and varying soil conditions.

F. C. de Nie, Holland

1386. J. Tâche, Contribution to the theory and calculation of lining for a circular tunnel (in French), Bull. Tech. Vevey 9, 19–28 (1949).

The object of the paper is the computation of stresses in a hydraulic tunnel, consisting of a steel lining, a layer of concrete, and the surrounding rock. Using the well-known formula for a thick-walled tube subjected to internal and external pressure, the problem is solved under two different assumptions: (1) all three layers consist of elastic materials; (2) the concrete and a certain zone of the rock have radial cracks and therefore no hoop stress. The limit of the cracked zone follows from the tensile strength of the rock. W. Flügge, USA

1387. C. Torre, The stress state in a heavy soil (in German), Öst. Akad. Wiss. Math.-Nat. Kl. S.-B. IIa, 156, 583–592 (1948).

This is a somewhat revised version of the paper of Rev. 3, **1178.** A half-space is assumed to be filled with uniform grains of approximately uniform size subject to gravity but without cohesive forces. The plane boundary may form any angle with the direction of gravity. Such a situation would be approximated by a thick deposit of loose sand which everywhere had attained the angle of frictional repose under the overlying uniform load. The author applies the method of envelopes, which he assumes to be of paraboloid form, to determine the stress distribution and the families of slip surfaces under "plastic" flow. In view of the assumed symmetry, he restricts his analysis to two-dimensions. He refers to another previous article [Öst. Ingen.-Arch. 1, 36–50 (1946); 316–342 (1947)]. The results are presented in tabular form.

Courtesy of Mathematical Reviews J. B. Macelwane, USA

1388. M. G. Spangler, Stresses and deflections in flexible pipe culverts, Highw. Res. Bd. Proc. 28, 249–259 (1948).

A comparison is given of the deflections of flexible pipe culverts as measured during experiments at North Carolina and at Iowa, and as computed by means of the Iowa formula. Good agreement is claimed but details are lacking concerning the suggested methods for evaluating in advance of construction the numerical values of the "bedding constant," the "deflection lag factor," and the "modulus of passive resistance" contained in the formula. A distribution of soil pressures is assumed which is not in agreement with the results of other more recent studies [see Rev. 2, **1462**]. Gregory P. Tschebotarioff, USA

1389. A. Hrennikoff, Analysis of pile foundations with batter piles (Spanish translation), Informes Constr. 2, no. 17, 20 pp. (1950).

See Rev. 3, **178.**

1390. A. Coüard, Determination of the resistance of piles driven into pulverulent soils (in French), Génie Civ. 126, no. 8, 144–147 (Apr. 15, 1949).

In a discussion of the problem, treated in a mainly qualitative manner, the author concludes that the difficulties of predicting the bearing capacity of piles from the results of soil tests and theoretical analyses, such as that of Caquot, are too great for practical use. He recommends the use of in-situ tests, such as the Dutch deep-sounding technique, both in sands and clays.

A. W. Skempton, England

1391. **L. Leroy Crandall, Electrical resistance strain gauges for determining the transfer of load from driven piling to soil,** Proc. Sec. int. Conf. Soil Mech. Found. Engng. 4, 122–127 (June 1948).

Electric resistivity SR-4 strain gages were mounted at seven elevations on a 2-in-diam steel pipe imbedded in the concrete of a Raymond test pile. On two of the piles tested the gages were protected by beeswax only and gave erratic readings. On the third pile the gages were coated with vaseline first and their readings were consistent. However, the magnitude of the load measured on the inner steel pipe was three times greater than the values computed on the basis of the ratios of the moduli of elasticity of the steel and of the concrete, whereby the latter was determined on test cylinders. No explanation could be offered for this discrepancy. The measured decrease of load along the depth of the pile, however, followed a reasonable pattern.

Gregory P. Tschebotarioff, USA

1392. **Soil maps: Engineering use of agricultural soil maps,** Highw. Res. Bd. Bull. no. 22 (1949).

Soil maps as prepared by agricultural organizations for their own special needs may be adapted to engineering purposes for such projects as road and airport preliminary soil surveys. A very complete compilation of the available information for each state and county of the United States, with references as to where the detailed information may be obtained, renders this work invaluable to those specializing in the above-mentioned fields. The significance of those surveys to the engineer and the method of application of the information to airplane-landing strips are clearly demonstrated. Robert Quintal, Canada

1393. **Leonard D. Baver, Retention and movement of soi moisture,** in *Hydrology* ed. by O. E. Meinzer, Dover Publications, 364–384, New York (1949).

Retention of soil moisture: Under the subheading "Energy relations in the retention of soil moisture," the author treats mainly the Buckingham concept (which is one of force rather than of energy) and the subsequent developments by Gardner and Richards. With respect to "pressure deficiencies," the author gives the classical investigations of Slichter and King and the further developments by Haines. These developments are, of course, mainly for sands and gravels, and must be modified considerably before they become applicable to soils. Under the subheading of "Equilibrium points for characterizing the retention of soil moisture," attempts are discussed of correlating agricultural soil constants, such as the wilting point and hydroscopic coefficients, with pressure deficiencies expressed numerically in *pF* terms as defined by Schofield.

Movement of soil moisture: Unsaturated flow is, again, treated according to the Buckingham concept which, at best, is only a formalistic approach and not likely to give the type of kinetic picture required for fruitful theoretical development in this field. Film flow, which in recent years has proved so important in thermo- and electroosmotic drainage, is not mentioned at all, neither is the importance of temperature potentials which cause flow at moisture contents where surface-tension potentials appear to lose their practical importance for water conductance. Thermoosmotic moisture movement connected with the propagation of daily and seasonal heat waves into the soil is not covered at all, nor is due attention given to the complex molecular composition of liquid water or to the even more complex relationships between water films and solid internal soil surface.

The movement in saturated soils is treated in line with the concept of Darcy, developed further by Slichter, Zunker, Kozeny, and others. Emphasis is placed on modifications of pore space relations, neglecting the more important concept of internal surface/pore volume, in other words, "the hydraulic radius." No reference is made to available data on the effect of exchange ions on the permeability constants of whole soils.

While in the body of the paper the author appears to assume tacitly the correctness of the Rothamsted concept that capillary water is physically no different from free water, and which denies the presence of surface films with structures and energy contents characteristically different from those of free water, he keeps the back door open, mentioning by way of summary the hydration of the pores as one of the factors influencing movement of water.

It is significant that no reference is made to any work published after 1939. No utilization is made of modern physical and physicochemical concepts with respect to (a) molecular complexity of liquid water, (b) structure of adsorbed water, (c) flow as a rate reaction, and (d) susceptibility to quantum mechanical analysis. Hans F. Winterkorn, USA

1394. **P. Ya. Polubarinova-Kochina, On unsteady motion of soil water seeping from water reservoirs** (in Russian), Prikl. Mat. Mekh. 13, 187–206 (Mar.-Apr. 1949).

The paper presents and discusses at length the problem of unsteady seepage in the soil body, caused by a sudden change of the water level in an adjacent reservoir or canal. It is shown that, with some approximations, the problem may be reduced to the nonlinear partial differential equation of Boussinesq. Further approximations are needed to make the latter integrable. This is accomplished most conveniently by reduction to the linear equation of the type encountered in the heat flow, which is later applied to a number of specific cases. Derivation of the seepage equation in the form of the "telegraph equation" is also given.

Most of the specific cases considered belong to the two-dimensional type, with the flow occurring in XZ-plane. These comprise cases involving the following conditions: (1) The water surface in the ground is horizontal, prior to a sudden change of water level in an adjacent reservoir. The base is horizontal and impervious. (2) The same, except for an additional upward inflow, through a slightly pervious base. Two different conditions with regard to the initial ground-water surface are considered. (3) The impervious bottom is slightly curved. (4) Constant inflow of rain water from above. (5) A three-dimensional problem, similar to problem (1), except for the canal adjacent to the ground, having a dam in it, and the water, after a sudden change, standing at two different levels on the upstream and the downstream sides in the canal. (6) Two problems of radial flow similar to cases (1) and (4).

A seepage problem involving two different liquids, with the boundary surface between them not deviating greatly from a horizontal plane, is also discussed.

In general the presentation of the subject in the paper is highly mathematical and none too lucid. The resultant expressions for the ground-water surface and discharge are usually given in explicit finite form, sometimes in the form of definite integrals. Only in case (1) are the results illustrated by graphs. The extent of errors produced by various approximations is left unknown, although in case (1) the graphs presented make apparent the discrepancy in solutions arrived at by different methods.

Alexander Hrennikoff, Canada

1395. **V. V. Sokolovskii, On nonlinear filtration of ground water** (in Russian), Prikl. Mat. Mekh. 13, 525–536 (1949).

See Rev. 3, **517.**

1396. **Reginald A. Barron, Viscous flow tube model,** Proc. Sec. int. Conf. Soil Mech. Found. Engng. 3, 209–211 (June 1948).

An analogy is shown between the equations governing the variations of pore-water pressures in a foundation soil, caused, e.g., by a variation of load, and the continuity equation for the varied viscous flow in a tube. On this analogy a method can be grounded for the study of the water pressures in soils by a viscous tube model. Some experiments conducted in the Soils Laboratory of Providence District, Corps of Engineers, are described. The possibility is also indicated of analyzing by a similar model the phenomenon of the penetration of frost into a soil due to variable surface temperatures. Duilio Citrini, Italy

1397. U. M. Shekhtman, Filtration of weakly concentrated suspensions (in Russian), Izv. Akad. SSSR Ser. tekh. Nauk no. 3, pp. 343–353 (Mar. 1949).

The motion of a weakly concentrated suspension through a porous medium and the clogging of filters are analyzed. The volumetric concentration of the suspension is assumed known. Equations are then developed which relate the discharges of the liquid and of the solid phases of the suspension per unit of filter area to the degree of saturation of the pore space of the filter by the liquid, and to the degree of its clogging by the solid phase of the suspension, as well as to the pressures at any point of the filter. Experiments are described the results of which confirmed the general theoretical deductions made, and verified the hypothesis according to which the coefficient of permeability of the porous medium is linear in the degree of saturation (clogging) of the pore space by the fraction of the solid phase of the suspension which had settled out in the pores. Gregory P. Tschebotarioff, USA

Micromeritics

(See also Revs. 1277, 1366, 1397)

1398. M. Vasseur, Collection of suspended particles by a body of revolution in an air stream: method for a sphere (in French), Rech. aéro. Paris, 61–64 (May-June 1949).

The methods for determining the deposition of particles from an air stream on an object placed in the air stream are extended to solids of revolution. A previous paper by Ed. Brun and M. Vasseur [J. Rech. Centre Nat. Rech. Sci. no. 3 (1947)] developed the case of cylindrical objects and gave fundamental definitions. General methods are given for tracing the streamlines and determining the velocity at any point in the stream. The deposition of 12, 20, 30, and 40-micron water droplets on a sphere is worked out in detail for the case of sphere 40 cm in diameter in an air stream with a velocity of 90 meters per sec. The coefficients of deposition, i.e., ratio of surface covered with the droplets to the cross-sectional area presented by the obstacle in the stream, increase as the particle size of the droplets increase. Calculations show that the maximum concentration of the material deposited is in a circular zone some distance away from the axis of the revolution parallel to the direction of flow.

C. Ross Bloomquist, USA

Geophysics, Meteorology, Oceanography

(See also Revs. 1306, 1318)

1399. C.-G. Rossby, On the dispersion of planetary waves in a barotropic atmosphere, Tellus 1, 54–58 (Feb. 1949).

This paper deals with dispersion phenomena of solitary atmospheric disturbances, especially long-wave disturbances. Numerical data are presented on the rate of dispersion of such disturbances, especially the maximum speed at which the "influence" of a disturbance is propagated into the environment. Gravity waves and acoustic waves are neglected. It is found that, in general, dispersion increases rapidly with increasing dimensions of the system considered, up to a certain maximum wave length. Rapid dispersion will be found in low latitudes, but slow dispersion only in high latitudes where solitary disturbances of large dimensions may show a considerable persistence with time. With the help of a frequency equation derived from the general vorticity equation $d[(f + \zeta)/D]/dt = 0$ (f Coriolis parameter, ζ vertical component of vorticity, D depth of the atmosphere), phase- and group-velocity curves are plotted which indicate that, e.g., in the westerlies of the northern hemisphere a wave length of $^1/_3$ of the circumference of the earth is dominant.

The results have been derived for the cases of a barotropic atmosphere only by studying plane waves of small amplitudes superimposed on a constant westerly wind current. A fuller treatment of the problems involved will be found in T. C. Yeh's paper [J. Met. 6, no. 1 (1949)]. Horst Merbt, Germany

1400. Jacob Zwart, On the relationships between the advection theories (in German), Met. Rdsch. 2, 1–5 (Jan.-Feb. 1949).

This paper contains a short summary and comparison of all advection theories so far known. Simplified derivations of all important advection formulas are given to prove that most of these theories are covered as special cases by Ertel's general advection equation (see H. Ertel, *Methoden und Probleme der dynamischen Meteorologie*, Berlin, 1938). Horst Merbt, Germany

1401. Ya. I. Sekerzh-Zen'kovich, On the influence of the form of the shore line on the strength of the monsoon field (in Russian), Izv. Akad. Nauk SSSR. Ser. Geograph. Geophys. 13, 194–211 (1949).

Schuleĭkin [*Physics of the sea*, Akad. Nauk. SSSR, part V (1941), 414–420 and 422–426 (in Russian)] has set up for the so-called temperature anomaly $\tau(x,y)$, caused in winter by the transfer of accumulated heat from the sea to the atmosphere, the following differential equations:

$$\tau_{xx} + \tau_{yy} - \kappa_1^2\tau + b^2 = 0 \qquad (1)$$

$$\tau_{xx} + \tau_{yy} - \kappa_2^2 = 0 \qquad (2)$$

where $\kappa_1^2 = (\sigma + \alpha)/ah$, $\kappa^2_2 = \sigma/ah$, $b^2 = \alpha\tau_w/ah$. Here σ denotes a coefficient which characterizes the dissipation of heat in the interplanetary space; α, a coefficient characteristic for the transfer of heat from sea to atmosphere; τ_w, the free surface temperature of the water which is supposed to be constant; a, some coefficient connected with the turbulence of the air; and h, the height of the active monsoon layer. Equation (1) must be fulfilled over the sea, equation (2) over the continent.

The boundary-value problem consists here of the equations (1) and (2) and the boundary condition which assigns a constant value to the function $\tau(x,y)$ along the shore line of the island. The author gives the solution in the cases of an elliptic island and a parabolic peninsula. It is shown that against an acute cape the strength of a monsoon field increases greatly.

E. Leimanis, Canada

1402. Horace R. Byers and Louis J. Battan, Some effects of vertical wind shear on thunderstorm structure, Bull. Amer. met. Soc. 30, 168–175 (May 1949).

This paper is one of the series of papers covering the work carried on under the Thunderstorm Project.

Use was made of a radar set having a range-height indicator to construct a three-dimensional model of the cloud as observed by the radar. By constructing such a model for different stages of development and dissipation of the thunderstorm, the effect of

wind shear in blowing off the top of a thunderstorm is illustrated.

By consecutive observation through a given cross section of a thunderstorm, the magnitude of the rate of displacement of the cloud at altitude H_2 relative to H_1 in a given direction was determined. Comparison of this rate of displacement with the vector difference of the wind velocity at altitudes H_1 and H_2 (as determined by winds aloft stations) showed that a definite relationship exists between the wind shear and the resulting radar-cloud shear at a given level. In almost every case, the wind shear is greater than the cloud and is attributed in part by the author to the fact that the cloud tends to build on the side of the cloud upstream along the shear vector.

Data, having considerable scatter, are presented which indicate that the maximum height attained by a thunderstorm cloud is dependent to some extent on the magnitude of the wind shear; the greater the wind shear, the lower the maximum height.

Radar photographs are presented which show that, under certain conditions, the top of a cloud is displaced because of the wind shear and a new top will develop. The author suggests that this process may be instrumental in producing the downdraft, inasmuch as the displaced top will permit hydrometers to fall outside of the updraft region, thereby producing the downdraft as a result of the viscous forces between the falling particles and the surrounding air. J. E. Dinger, USA

1403. E. J. Smith, Experiments in seeding cumuliform cloud layers with dry ice, Austral. J. Sci. Res. Ser. A 2, 78–91 (Mar. 1949).

Five experiments are described in which ice crystals were introduced into supercooled waterdrop clouds by seeding these clouds with dry ice. The selected clouds generally changed into ice-crystal clouds and artificial precipitation was induced to fall which reached the ground in two cases (height of bottom of cumulus in these cases about 4500 ft). Interesting optical phenomena could also be observed. Horst Merbt, Germany

1404. Richard A. Craig, Vertical eddy transfer of heat and water vapor in stable air, J. Met. 6, 123–133 (Apr. 1949).

The author carries out an analysis of an extensive series of vertical soundings of temperature and humidity which were made over Massachusetts Bay at distances from the shore of from 2 miles to 50 miles. In each of the groups analyzed the air came off the land in a well-mixed neutrally stable condition. This air was then cooled, stabilized, and moistened by diffusion from the sea surface. The data are separated into groups having different thermal stabilities, and analyzed by assuming that the vertical transport of moisture is due only to eddy diffusion. The values of the eddy diffusivity coefficient thus found are in general agreement with values of the thermal exchange coefficient obtained by Schmidt (1925) from air-temperature measurements on the Eiffel Tower, and by Taylor (1915) from air-temperature measurements taken over the Grand Banks of Newfoundland.

It is also shown that a simple model, having an eddy-diffusivity coefficient which varies linearly with altitude for a very narrow layer near the sea surface and is constant above this layer, gives a good approximation to the observed distribution of moisture. A simpler model in which the eddy-diffusivity coefficient is everywhere constant is also discussed and is shown to be much less satisfactory. H. J. Stewart, USA

1405. F. A. Vening Meinesz, Convection-currents in the earth, Proc. Kon. Ned. Aka. Wet. 50, 237–245 (Mar. 1947).

The author advances the hypothesis that convection currents in the subcrustal layer may be responsible for the intermediate and deep focus earthquakes associated with island arcs. The large negative-gravity anomalies typical of island arc structures suggest that a portion of the earth's crust was down-buckled to form a bulge of less dense, more radioactive material in the subcrustal layer. The author approximates the bulge by an infinite horizontal cylinder having a cross-sectional area of 1700 km², and assumes reasonable values for the thermal diffusivity and excess radioactive heat developed. Simple calculations show that a time lapse of 18,000,000 years is required to raise the temperature at the surface of the bulge by 85 deg. Stresses induced at this time by hydrostatic adjustment to the thermal expansion of the substratum are of the order of magnitude of the strength limit. Further heating initiates a current which because of the normal vertical temperature gradient assumes the character of a convection current. Topographic expression of the convection current takes the form of a difference in elevation of about 4 km between areas over rising and sinking columns of the current. The author further suggests that the abnormal cooling of the earth in the vicinity of the convection current induces a disturbance of the thermal equilibrium of the earth of much greater size than that caused initially by the presence of the crustal coat. This could start a correspondingly larger convection current involving the whole thickness of the mantle to a depth of 2900 km. Here would be an explanation for the major cycles of orogeny recognized in the geologic history of the earth.

The reviewer believes that the order of magnitude calculations given by the author are based on reasonable, though simplified, assumptions. The results indicate that convection currents in the mantle are feasible and may well produce the forces which have molded the earth's crust. Frank Press, USA

1406. Adalbert Prey, On the theory of land bridges and the earth viscosity (in German), Österreich. Akad. Wiss. Math.-Nat. Kl. S.-B. IIa. 156, 593–624 (1 plate) (1948).

The author attempts to find a mechanism corresponding to the theory of land bridges across the Atlantic and Indian oceans. He considers the sinking of a round continent (radius 2000 km, thickness 30 or 50 km) or of a circular plate, which at the initial time lies on a viscous substratum. The solution of the problem is based on a solution of the simplified equations of motion given by H. Lamb [*Hydrodynamics*]. The continent is represented by an expression containing the first 16 spherical harmonics. A differential equation of motion is given and the depth and velocity of sinking are calculated for various coefficients of viscosity of the substratum.

Courtesy of Mathematical Reviews W. Jardetzky, Austria

1407. Hydrology, edited by Oscar E. Meinzer, New York, Dover Publications, 1949, xii + 712 pp. Cloth, 6.5 × 9.5 in., $4.95.

This volume IX of the series "Physics of the earth" published under the auspices of the National Research Council, appeared originally in 1942 and has been now reprinted. It contains an introduction by Meinzer and the following fourteen chapters by various authors: II. Precipitation, by Bernard; III. Evaporation from free surfaces, by Harding; IV. Snow and snow surveying; Ice, by Church; V. Glaciers, by Matthes; VI. Lakes, by Harding; VII. Infiltration, by Sherman and Musgrave; VIII. Transpiration and total evaporation, by Lee; IX(A). Soil moisture and capillary phenomena in soils, by Terzaghi; IX(B). Retention and movement of soil moisture, by Baver; X(A). Occurrence, origin and discharge of ground water, by Meinzer; X(B). Movement of ground water, etc., by Meinzer and Wenzel; XI. Runoff, in nine parts, by different authors; XII. Droughts, by Hoyt; XIII. Physical changes produced by the water of the

earth, in five sections, by different authors; XIV. Hydrology of limestone terranes, by Swinnerton; XV. Hydrology of lava-rock terranes, by Stearns.

Of these, II, III, IV, V, IX(A), IX(B), and XV are being reviewed separately. Ed.

1408. François E. Matthes, Glaciers, in *Hydrology*, ed. by O. E. Meinzer, New York, Dover Publications, 149–219 (1949).

This paper is an excellent discussion of the new factual knowledge concerning the physical character of glaciers, their alimentation, régime and motion that has been gathered during the last few decades. Recent researches have demonstrated that glacier ice in large masses behaves under its own weight as a plastic solid. It does so because, when subject to prolonged differential pressure, the ice granules recrystallize and the new crystals tend to assume positions favorable to their deformation by the gliding of their basal plates. This inherent capacity of glacier ice for plastic deformation permits a slow flowlike motion of glaciers initiated by the force of gravity. Those glaciers that have beds of sufficiently high gradient to flow under the direct pull of gravity, flow much as streams of water do, the differential movement being typically unidirectional, organized around a central current or line of maximum velocity at or near the middle of the surface, and decreasing both laterally toward the sides and downward to the bottom (ice streams). When, on the other hand, the bed is basin-shaped, or has a gradient too low to overcome the frictional resistance of the channel, flow is induced by differential pressure within the ice mass itself (see below). Under these conditions outflow is most rapid in the basal portion of the section. Those ice masses that lie spread out broadly over land areas of such configuration that direct gravity flow cannot take place, develop flowage by reason of the same differential pressures within themselves (extrusion flow). It is typically multidirectional, proceeding from the central area of greatest height radially out towards the thinning margins. Ice masses of this class are termed ice caps. Wherever the plastic flow of glacier ice is obstructed by slower moving masses, shearing movements occur along narrow zones of recrystallization and along discrete fault planes.

The author also discusses the recent motions of glaciers viewed in their relation to the Pleistocene ice age. L. J. Tison, Belgium

Lubrication; Bearings; Wear

(See also Rev. 1240)

1409. Ch. Hanocq, Research on indirect friction (in French), Hommage Faculté Sci. appl. Univ. Liége, 149–167 (1947).

The paper synthesizes the substantial work on "indirect" friction, that is the friction of lubricated surfaces, which has been carried out since 1928 at Liége University, Belgium, by the author and his coworkers, E. Bodart and L. Leloup. The work, which hitherto had only been published fragmentarily, refers to three distinct types of lubrication: hydrodynamic lubrication, thin-film lubrication, and what is called "semifluid" lubrication, which is defined as the type of lubrication occurring between two strictly parallel surfaces. The objectives were to establish a firm theoretical and experimental basis for the prediction of the mechanical efficiency of machine parts, including those with alternating motion, and of their steady running temperature, particularly of plummer blocks. However, the reviewer does not consider all of the generalized relationships, which were arrived at by including results obtained by others, to be as widely applicable as suggested by the author. The interesting finding that, in the plummer block investigated, the coefficient of friction in the region of thin-film lubrication was not a function only of the nondimensional hydrodynamic parameter $\mu N/P$ (in common American notation: ZN/P), but of $\mu N/P^{1/4}$, can probably be explained by the reviewer's hypothesis (see his paper: "Fundamental mechanical aspects of thin-film lubrication," read before the N.Y. Acad. Sci., March 3, 1950), that the elastic distortions, caused by the bearing loads imposed, played an important role by reversibly changing the geometry of the bearing surface.

H. Block, Holland

Marine Engineering Problems

(See also Revs. 1268, 1272, 1300, 1311, 1354, 1363)

1410. W. P. A. van Lammeren, Some designs for the improvement of the efficiency of ship propulsion (in Dutch), Schip en werf 16, no. 7, 137–144 (Apr. 1948).

One of the main reasons for energy loss in the propulsion of single-screw ships is the peripheral unequality of the wake flow in the propeller. The author reports the results of systematic propulsion tests with ship models of various stern forms carried out in the Wageningen Model Basin. The object was equalizing of the wake flow by the use of streamlined nozzles placed in front of the propeller. Good results were obtained with unfavorable V-form sterns, but little improvement with well-designed club-footed sections.

The Schnitger propeller, very popular in Germany, was also tested. This screw has a streamlined ring between the blades. These experiments will be continued as this design seems promising, particularly for heavy loading. L. Troost, Holland

1411. A. F. Lindblad, Some experiments with models of high speed ships. The influence of block coefficient and longitudinal centre of buoyancy, Trans. Instn. nav. Archit. Lond. (1949); transl. from Ship en werf 16, no. 14, 288–296 (July 1949).

In this paper an account is given of a class of high-speed ships with speed-length ratios between 0.80 and 0.95, and block coefficients between 0.575 and 0.625.

By combining six forebodies and seven afterbodies of varying fullness, 28 combinations have been formed and investigated in 10 series. The models were 20 ft long. The results have been computed as resistance-constant values on the basis of speed, and analyzed for center-of-buoyancy location for minimum resistance. Very useful diagrams are presented. They show that for the majority of forms of this class, the LCB can be placed anywhere between 2 and 3% aft of $L/2$ to retain a minimum of resistance. These forms are essentially designed for twin-screw ships. A large amount of information is stored in this paper.

L. Troost, Holland